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THE LUIZ I. BRIDGE, OPORTO.

WE conclude in the present number our series of illustrations of this interesting structure. For the description of the engravings here given and for other illustrations, see our preceding SUPPLEMENT, No. 557, page 8888.

THE COLD ZONE IN WATER VESSELS.

By T. FLETCHER, F.C.S.

DURING my experiments on the state of things in that almost unknown space between a flame and a vessel containing water, some most extraordinary facts have come to light, which are not only of the greatest importance to steam users and boilers makers, but explain many curious points in connection with the heating of water.

It is well known that a flame does not come in contact with any ordinary vessel containing water, and that a paper label will remain on the bottom of a tin or copper kettle placed on a sharp fire, until by drying it gradually becomes loosened, and loses its contact with the metal, and so becomes burnt. I have myself seen labels on the bottoms of ordinary kettles and pans, the labels being quite perfect after some weeks' use over gas burners and fires. The work obtained from any source of heat by a limited surface is in direct proportion to the difference between the temperature of the vessel and that of the source of heat in absolute contact with it, and it therefore becomes a matter of serious importance to discover what the actual temperature of this cool and flameless zone is, and whether it can be removed. As is no doubt well known, my efforts to remove this, which is practically a wet blanket, from between the vessel and the fire have been partially successful by the use of projecting studs or webs of definite proportions, and the experiments already published prove that at the ends of copper rods four diameters long, flame contact exists, at all events sufficient to char paper, and to multiply the available duty, surface for surface, six times as compared with either water tubes or ordinary boiler plates, and that the evaporating power of any properly proportioned studded or ribbed plate has no limit except the practical one of removing the steam quick enough to prevent it lifting the water bodily out of the boiler.

After proving beyond doubt that under ordinary conditions flame does not come in contact with a vessel containing water, I endeavored to get this contact, and the corresponding increase in evaporating power, by directing flame against the water vessel with the assistance of a powerful blast, the result being, much to my surprise, that I found an impenetrable cold zone surrounding the vessel, absolutely impassable not only to a powerful blow-pipe flame, urged with an air blast of 1¼ lb. per square inch pressure (the heaviest blast a gas blow-pipe flame will stand under ordinary conditions), but that it was equally impassable by radiant heat from a sheet of white hot platinum, held as close as possible without absolute contact. In making these tests, the result was proved by the fact that sheets of paper pasted on the water vessels were exposed to both the direct impact of the blow-pipe flame and also to the radiant heat from the platinum, until the water in the vessel boiled, the paper being perfectly free from charring or discoloration at the end of the test.

Another important fact came out as the result of these experiments. Not only can the maximum temperature be determined by the presence or absence of charring of known organic substances, but also the thickness or depth of the cold zone can be measured by using paper of different thicknesses pasted to the surface of the vessel. When the paper used is thicker than the depth of the cold zone, the surface is charred or completely burnt to an invariable depth by each source of heat; but if this charred surface is cleared off with glass paper, the under part will be found perfectly white and clean, and on again directing the flame on this clean surface, it remains untouched.

Another curious and important fact is that this cold zone, although impassable by flame, hot air, or radiant heat, is powerless to resist the carrying of heat through it by solid bodies, and while the blow-pipe flame is being directed on the paper without the slightest effect, a wire passing through the flame and touching the paper will burn it instantly and completely, although the actual temperature of the wire must of necessity be far below that of the blow-pipe flame.

The extraordinary part of the whole series of experiments seems to be the existence of a zone of cold against all surfaces of metal having water behind them, this space being, to radiant heat and flame, almost as impenetrable as the metal itself is to the water. Some heat certainly does pass, or the water would never boil; but the quantity which does make its way through is very trifling as compared with what would pass, and, in fact, what does pass under such conditions as permit of direct flame contact with the metal.

The result of these experiments does not fit the ordinary accepted theories of radiation and absorption of heat. The fact is that the high temperature stops suddenly at a very clearly defined distance, the division line being sharply drawn. It cannot be said that the heat is absorbed at a sufficient speed to produce this cold zone, because, as a matter of fact, the heat rebounds and is dissipated to a large extent sideways, and this rebound takes place at an invariable distance from the vessel, irrespective of the angle at which the flame is driven and depending only on the force of impact of the flame. If we could imagine the surface of the vessel covered with a layer of elastic material which is compressed by a torrent of small shot driven steadily against it, we get a mechanical representation of the actual state of things between a flame and a cold vessel, additional force of impact reducing the thickness of the elastic layer, but being powerless to annihilate it.—*Industries.*

FIG. 4.—MOUNTING OF THE ARCH.

FIG. 1.—LUIZ I. BRIDGE IN PROCESS OF CONSTRUCTION.

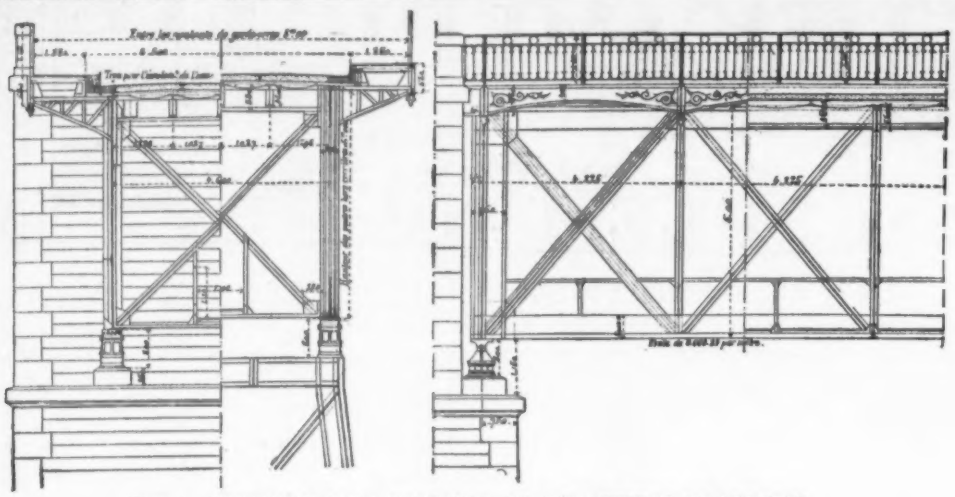


FIG. 2.—ELEVATION OF SECTIONS OF THE UPPER PLATFORM.

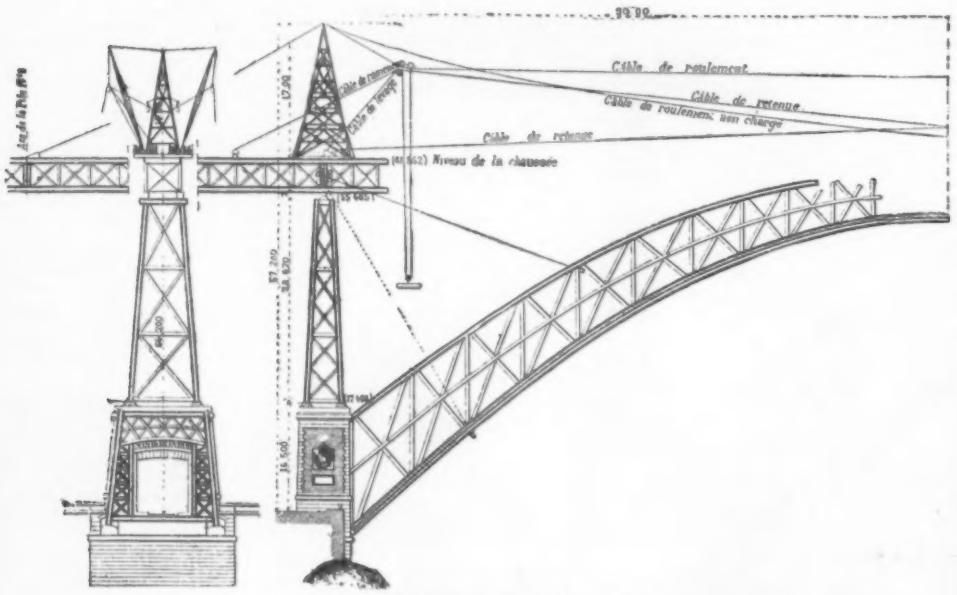


FIG. 5.—MOUNTING OF THE ARCH.

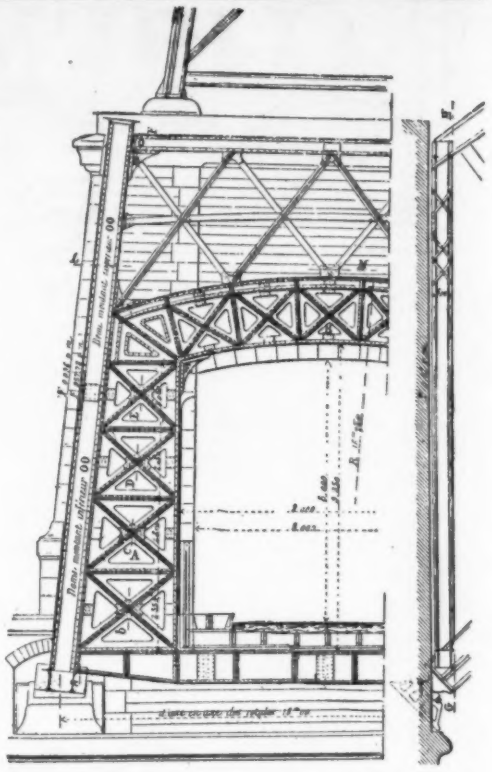
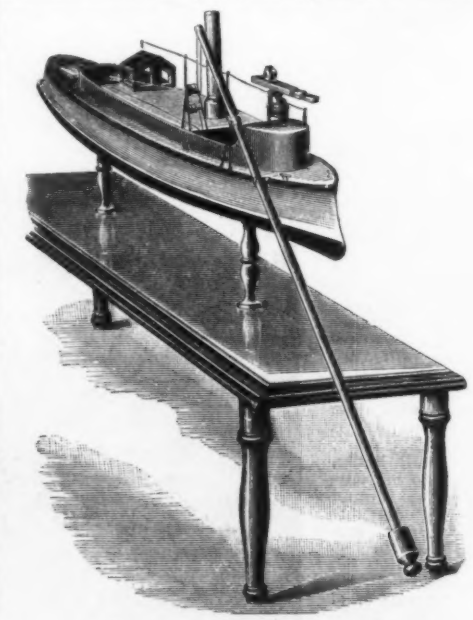


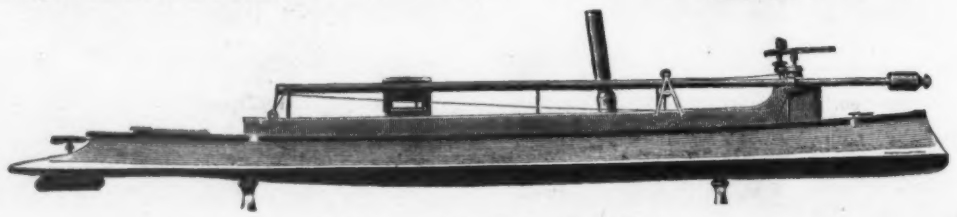
FIG. 3.—ELEVATION AND SECTION OF GATEWAY.

Two of these boats have been used for the purpose of exploring and patrolling rivers. These have each been fitted with a Nordenfelt bullet gun, which can be worked under cover of an arrow-proof wire netting, so as to afford protection in dealing with Indians. The maximum draught stipulated for these boats was 13 in., and the speed was guaranteed at 12 knots per hour. These boats were built in three sections for purposes of transportation. Three other boats were fitted with a MacEvoy outrigger torpedo, in addition to the Nordenfelt gun; both of these may be seen in the illustration. The bottoms were sheathed with wood outside the steel plating. The thickness of this skin was 1 in. On this account the maximum contract draught was increased to 14 in., and the speed reduced to 11 knots.

In making an attack, full pressure would be got up in the boiler, and the exhaust steam would be ejected below the water line so long as the approach of the boat was undiscovered. When silence would be no longer of use, the exhaust would be turned into the chimney, and the boats would rush up at full speed. The outrigger can be run out from the conning tower, so that the torpedo is carried 16 ft. from the bow. When within striking distance, the end of the pole would be dropped into the water, so as to injure the enemy's ship below her water line. The position of the torpedo ready for exploding is shown. The torpedo can be fired either by contact or by pulling a trigger.

The displacement of the sheathed torpedo boats on trial, with steam up, fuel, crew, stores, torpedo, gun and ammunition complete, was 3½ tons, the draught





SMALL TORPEDO BOATS.

THE LUIZ I. BRIDGE, OPORTO.

LIFE AND PROFITS OF A CAR.

Paper read by E. C. SPALDING, of the Western & Atlantic Railroad, at the Car Accountants' Convention, at Buffalo.

THIS is a very important subject, and one which has been somewhat neglected. When we consider the cost of equipping a road with cars, the expense to keep them in repairs, and mileage earned, we at once have three very important subjects which involve an enormous amount of capital. An investigation of the subject cannot fail to be interesting, and we shall find some important suggestions presented during our examination. Taking the value of a car as a basis, its mileage as revenue or profit, and the repairs as expense, we are sometimes astonished at the vastness of the interests intrusted to our care. A car will cost, on an average, $500. A road owning 1,000 will have invested $500,000; a road operating 10,000 will expend $5,000,000 in equipping itself, etc. During 1882 our management required me to keep an individual mileage record of each car, and, as we were then in the South interchanging daily reports of movements and mileage, I was able to compile my tables from actual figures, and not estimates. A road, as we before mentioned, secures its cars at an immense expense. These cars are then turned loose upon the country, and are expected to earn a reasonable interest on the investment. We see at a glance what an important department in railroads this is. The question then is, What is the revenue and expense involved, and what profit to a railroad is a car? This, of course, depends upon the age and condition of a car. Below I present a table showing the average mileage made by our cars of various ages, also repairs done, thus giving the average revenue, expense, and net loss or profit (or original cost) by cars of various ages:

EARNINGS AND COST OF BOX CARS IN GENERAL SERVICE.

Age of car, years.	Mileage run.	Money earned.	Cost of repairs.	Net profit.	Per cent. of profit.
1.....	13,149	$98.62	$9.58	$89.04	18·00
2.....	13,478	101.08	38.13	62.95	12·50
3.....	10,475	78.56	48.24	30.32	6·00
4.....	9,847	73.85	45.85	28.00	6·00
5.....	9,841	74.11	57.31	16.80	3·00
6.....	9,349	70.12	70.74	*.62	*0·11
7.....	8,968	67.26	60.74	6.52	1·25
8.....	9,270	69.37	55.49	13.88	2·80
9.....	9,395	69.71	49.80	19.91	4·00
10.....	7,656	57.42	53.67	3.75	0·75

* Loss.

It will be noticed that for the first five years cars make good mileage, and will average 9 per cent. profit on the investment; but during the next five years the mileage decreases, repairs increase, and the net profit is reduced to an average of 1·6 per cent. This suggests that for the first five years of a car's life it is a good investment, but after that it is not profitable to run them as an investment. For the first five years a car will net 9 per cent. on the investment, or about half pay for itself in mileage; after that it is almost "nip and tuck" between mileage and repairs for the next five years. The life of a car depends altogether upon how long a road is willing to patch it up with repairs. I believe we have an occasional car now in service which was built 20 years ago, but I apprehend that very little of the original cars remain, and that it has been more expensive to keep them up than it would have been to have destroyed them and used the old iron in the construction of new cars. These figures prove, I think, that mileage at the rate of ¾ cent per mile is not excessive, and results only in a fair profit on the investment.

TORPEDO BOATS.

WE publish two illustrations taken from a model of some remarkable little steel boats built by Messrs. J. I. Thornycroft & Co., of Chiswick, for the Brazilian Government. Five of these little craft were built, and they are, we believe, now running on the inland lakes of South America. They are 45 ft. long and 6 ft. wide, and are open launches with a single high-pressure cylinder of 6¼ in. diameter and 8 in. stroke. The boilers are of the locomotive type originally introduced by this firm. The steam pressure is 130 lb., and the draught is obtained by exhausting in the funnel in the usual way. So as to allow of the boats running without noise, an arrangement is provided for exhausting below water. The propeller is of Mr. Thornycroft's guide-blade type, or screw turbine. The diameter is 16 in., and it is carried in a hollow in the stern in the manner adopted by this firm, so as to allow of the small draught of water which is one of the leading characteristics of the boats.

13 in., or 1 in. below the contract, and the speed 12 knots, or one knot over the contract. In the unsheathed boats the draught was 11¼ in., the speed 13 knots. This was ¾ in. less draught and one knot more speed than the contract. The displacement when fully equipped was 3·14 tons, and the revolutions of the engines 534 per minute.—*Engineering.*

THE FARCY GUNBOAT.

THE first Farcy gunboat, which in the years 1870–71 co-operated in the defense of Paris, has not been forgotten. This type of boat has just been adopted for the construction of a new model that differs from the preceding only in dimensions, artillery, and arrangements.

The type devised by Mr. Farcy is especially remarkable for the form of its keel, which is undulatory, and a section of which has nearly the aspect of an inverted circumflex accent. The object of such a shape is to increase the load water line surface without injury to the stability.

The total length of the new boat, which recently went through some maneuvers on the Seine at Paris, is, inclusive of the beak, 67 feet. Her breadth amidship is 16½ feet, and her maximum draught astern is 2 feet, for 29 tons of displacement.

The motors, which are two in number, are vertical ones of an effective 40 h. p. The boiler, which is registered at 9 atmospheres, stands upon the main deck. The engines, which are independent, actuate two screws, and are capable of producing 500 revolutions per minute at any speed.

The Farcy gunboat is armed at the bow with a 5½ in. gun (Fig. 2) and two Hotchkiss revolving guns, of 1½ in. caliber, fixed upon the superstructure. The bow gun is protected by a steel plate shield, which secures the gunners against musketry. The extremity of the gun projects beyond the shield, and takes in a field of about 270°.

The steering wheel is placed under a large roof, and the straight tiller is in the rear, in the open air. The funnel projects above the roof, between the supports of two revolving guns. The hull is divided into sixty water-tight compartments.

At the recent trial trip made upon the Seine, the vessel ran as far as to the Invalides, then, going about in a circle 98 feet in diameter, she descended the current, ran along Cygnes Island, and sailed up again as far as to the Royal Bridge.

From this trial trip it seems certain that the vessel, when in her water lines, will reach, under any steam, a speed of from 7 to 8 knots.

When equipped for war, the boat will carry a crew

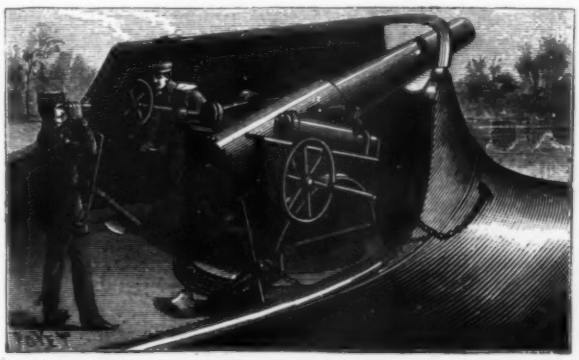


FIG. 2.—CANNON IN POSITION ON BOAT.

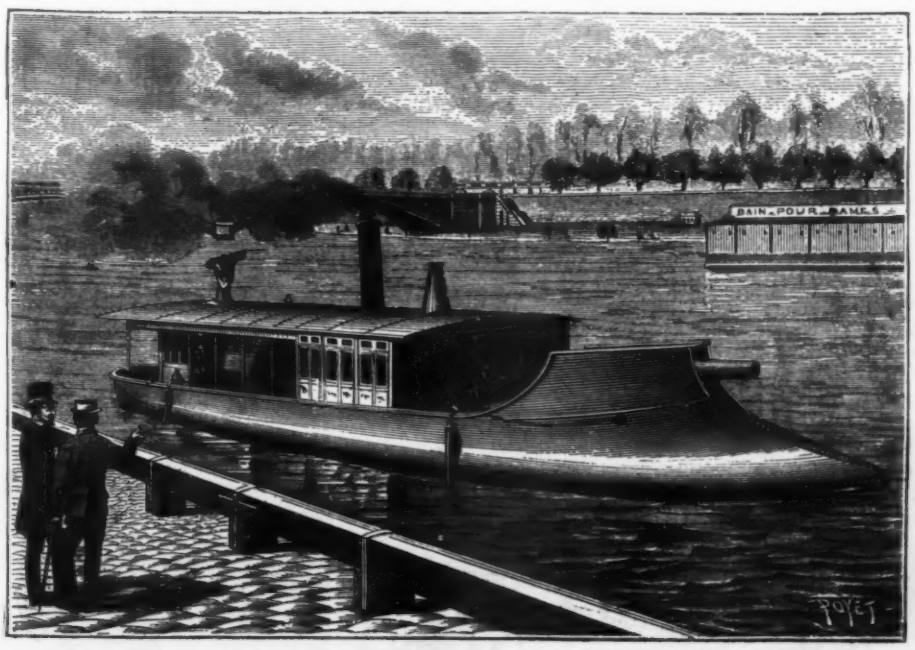


FIG. 1.—CANNON BOAT FARCY.

of twelve men. Her construction cost $5,800, a portion of which was derived from a subscription raised at the Chamber of Deputies.—*La Nature.*

FLOATING ISLANDS.—The floating islands of pumice, thrown up by the late stupendous volcanic eruption at Krakatoa, in the Javan seas, are found to have drifted in the Indian Ocean 676 miles in a direction west by south from the spot where they were a year ago.

MECHANICAL FEEDERS FOR WOOL CARDERS.

THE oldest known mechanical feeders for wool carders are those of Martin & Bolette, to which have been later added those of Geszner, Bohle, Klein, and Lemaire. Those of Geszner and Bohle are principally applied to the treatment of Vienna wools, resulting from the transformation of cotton rags mixed with coarse English noils. The Martin system, which is a little heavier, shares the favor of some, along with that of Bolette, and both are admirably adapted for working with fine and medium wools. Unlike the feed apparatus of other manufacturers, the first two keep the wool more open, and do not cause it to wind around the cylinders. Yet, up to the present, no known feeder has operated regularly enough to permit of dispensing with weighing the fleece before its passage to the second carder. There is in England, however, the King balance apparatus, constructed by Tatham, of Rochdale, the use of which is increasing for the working of good wools. Through the application of the principle of the balance to this apparatus, the latter feeds regularly in weight. But it must be said that in England the Collier system has been adopted, while almost everywhere on the Continent an entirely different one is in vogue. In the Collier system of receiving the wool in slivers, King's automatic feeder, made by Tatham, is rendering great services; but this it could not do with laps, which it is necessary to spread regularly over the whole width of the feeding surface. The difficulty is to combine a regular spreading and a constant weight of the laps in one and the same apparatus.

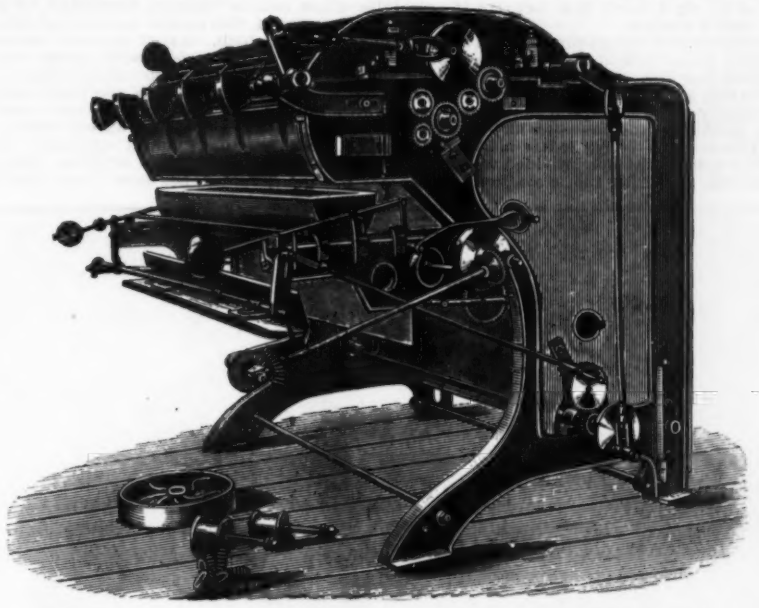
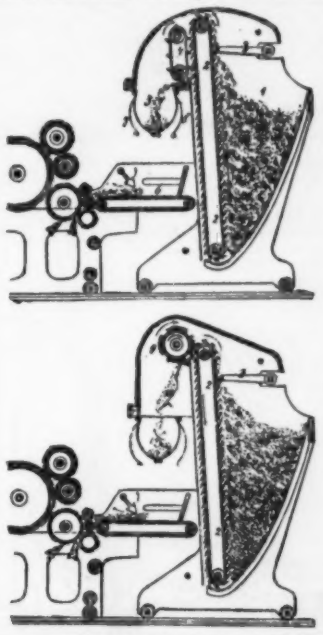


FIG. 1.—HAIGH'S MECHANICAL FEEDER FOR WOOL CARDERS.

In America, the apparatus used is the Bramwell feeder, of which we shall hereafter give further details. This apparatus is constructed with or without a balance, so that it can be applied to burr machines and willies as well as to carders.

Very recently, a new mechanical feeder has made its appearance in England, and has been well spoken of. Some even assert that this new system is so inapproachable that no future improvement can be made in it. It is being constructed by Messrs. John Haigh & Sons, of Huddersfield, who, for the last decade, have enjoyed a high reputation for their machines for treating carded wood, of which they make a specialty. The inventor of it is Mr. Amitage Haigh.

This machine is shown in an accompanying engraving (Fig. 1). The inventor employs the ordinary box, but modifies the usual arrangement of the endless



FIGS. 2 AND 3.—SECTION OF TATHAM'S FEEDER FOR WOOL CARDERS.

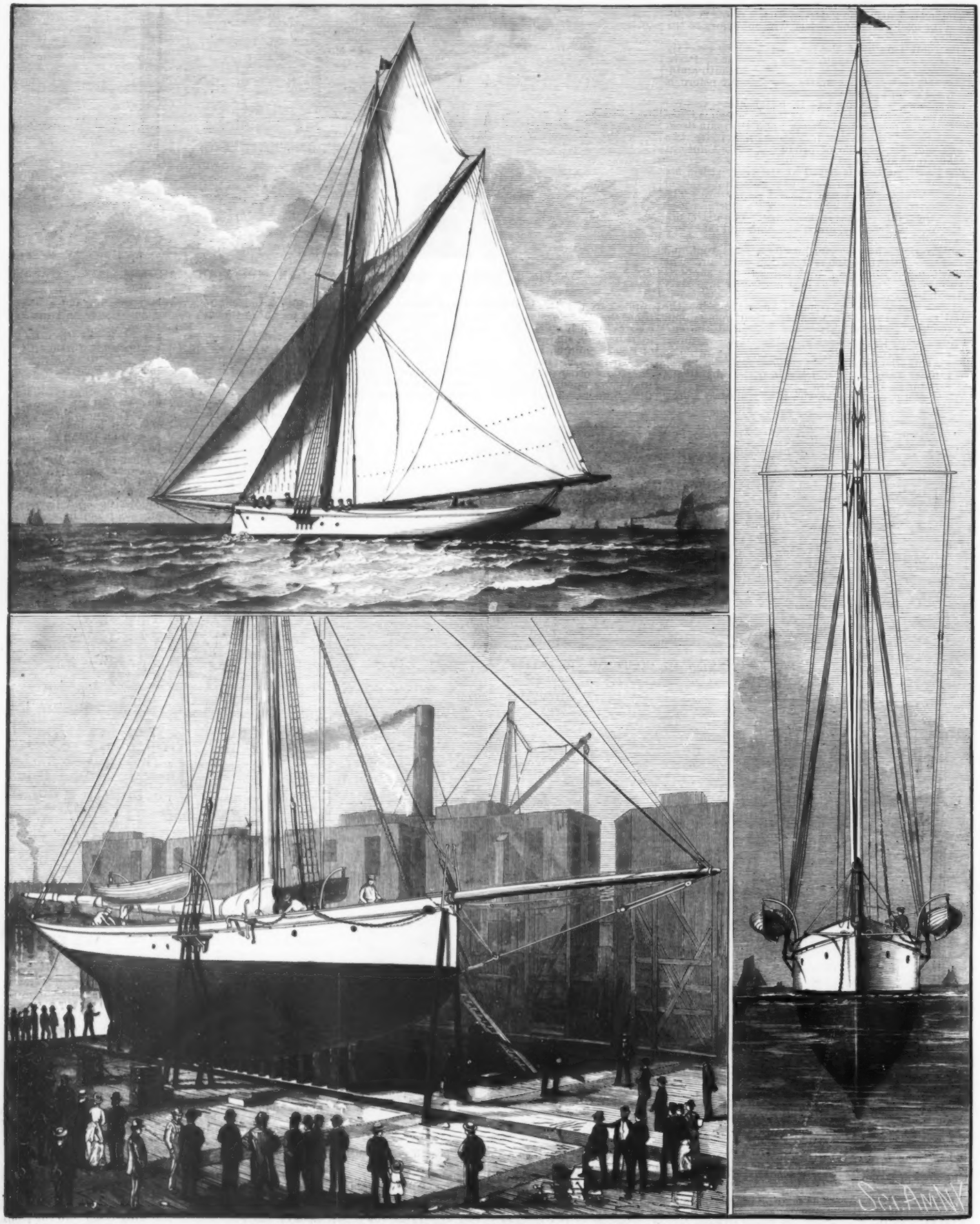
apron. This latter is so arranged as to present a steep inclination to the raw material that falls into the box. Its upper part passes over three rollers, whose arrangement is such that, when it is running over the first two, it forms a horizontal plane, and then, when it is between the second and third, it is in a vertical one. Above these three rollers are placed two others, over which runs another endless apron, which is provided with hooks, and the under side of which forms a plane surface of an extent corresponding to that of the first apron, and opposite it. These two endless aprons move in opposite directions, and their hooks open the wool that passes between them. The height of the second apron may be varied at will, so that, according to requirements, its surface may be removed from or brought near that of the lower apron, according to the nature of the wool that is being treated.

With this arrangement, it is easily seen that it is possible to obtain a wider carding surface than in other feeders. In the interior of the box there is also a swinging comb designed for removing the too bulky portions of the wool and for throwing them into the box. A similar comb (or a brush, or a combination of both, if desired) causes the wool to fall, in measure as it

moves along, into the scale. When this latter has received the charge for which it has been regulated, an automatic gearing stops the motion of the feeder until the scale has emptied its contents. Then the balance is brought to its former position by a peculiar mechanism, and this has the effect of setting the apparatus in motion again. All these motions are effected, not by belts, but by rigid parts that actuate the mechanism in a positive manner.

Let us now examine how things proceed in Tatham's mechanical feeder, whose action is shown in section in Fig. 2, and which has been greatly improved by Mr. De Werdan. In this apparatus, we remark a box, *l*, in which runs vertically an endless apron that passes over two rollers, one at the top and the other at the bottom of the box. The wool to be carded is placed in the box. The endless apron, which is provided with teeth, runs in the direction shown by the arrow, and carries along with it a certain quantity of wool. A comb (3) removes the excess of material carried along, the quantity of which may be regulated by varying the distance between the apron teeth. The wool, pressed between the teeth of the first apron, is caught on descending at the other side by a second endless apron (4), which also is provided with teeth, but which is much shorter than the other, and is likewise supported by two rollers. The velocity of this second apron is greater than that of the other, which, on that account, necessarily gives up its wool. From this second apron the wool falls into the scale of the balances (5), whose play is well known. The length of this receptacle is equal to the width of the feed table of the carder, and while the weighing is being done, the aprons come to a standstill. The weighings might naturally be varied as much as desired by means of weights. After the weighing has been effected, the jaws (7 and 8) of the scale (5) open and let the wool fall upon the table of the carder. As soon as the scale (5) is empty, the aprons are set in motion through the tilting that occurs at this moment. Through this arrangement of an ever the same quantity of wool falling upon always the same surface of the feed table, we necessarily reach a regularity in the preparations, which is the object sought. In this feeder, however, it happens that the apron (4) does not always completely take up the wool caught between the teeth of the apron (2), thus causing an irregularity in the feed, and consequently coarseness and fineness in the preparation, and which thus gives a too short or too great length.

Still another inconvenience in this machine is that the comb (3) continues its motion during the stoppage of the aprons, and thus removes all the wool from the apron (2) at the part opposite to it, and produces cross-cuts.



ILLUSTRATIONS OF THE BRITISH YACHT GALATEA.

The improvement noted above is as simple as it is important. It consists in substituting for the discharging apron (4) a wheel (9, Fig. 3), analogous to the one placed above and between the doffer and the large drum in wool carders. The wool no longer *falls* into the scale to be weighed, but *slides* gently along a piece of sheet iron (10), forming an inclined plane. The motion of the comb (3) and that of the apron (2) are interdependent, so that, when the latter stops, the comb stops too, and does not begin its motion again till the first apron starts.—*L'Industrie Textile.*

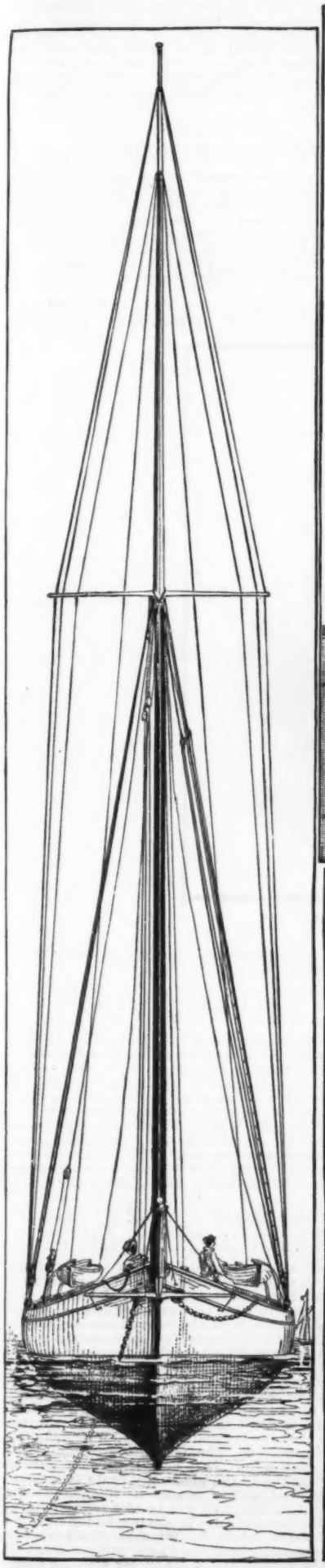
THE GALATEA AND MAYFLOWER.

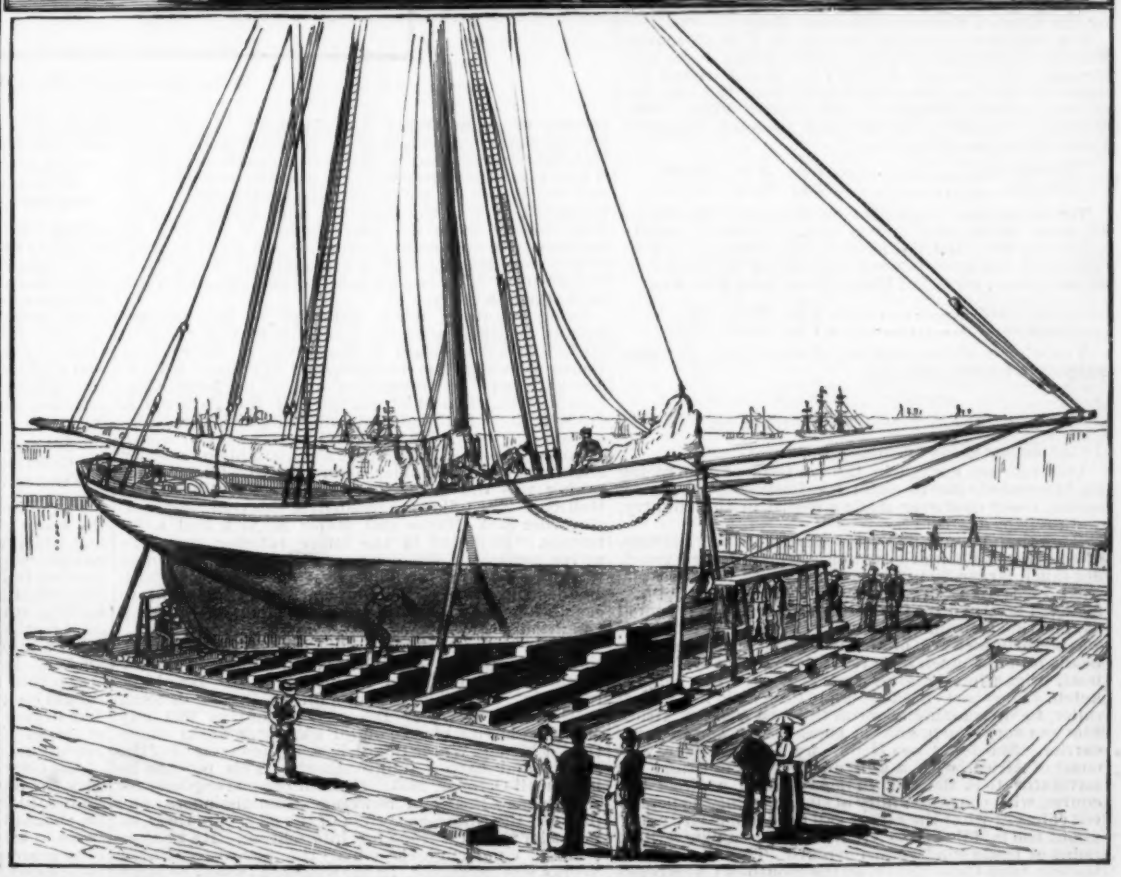
THE International Queen's Cup, won thirty-five years ago by the schooner yacht America, has again, after so long a sojourn in this country, become a subject of contest. The Galatea, an English keel boat, having had her challenge of 1885 extended so as to allow of her racing under it this year, has met the American centerboard yacht Mayflower for a series of inside and outside course races, to decide the future holding of the trophy.

The competitors are illustrated both under sail and as they lay in the drydocks. To show more accurately the general model, the bilge blocks have been omitted, the latter views thus exposing the whole side. They are nearly of the same length, the Mayflower being two feet the shorter. In breadth and depth they differ widely; the Mayflower is much wider and shallower. Being wider, she carries more sail than the Galatea, and is handicapped, having to allow the Galatea 38 seconds over the inside course.

In the Galatea's model will be recognized the convex lines of the conventional cutter. Her sheer is quite pronounced, an end elevation of the hull showing a sharp rise in the bow that is missing in the Mayflower.

In the comparative side views of the two yachts as they lay in the drydocks, further differences will be noticed. The Galatea has a strongly rocking or curved keel. This is an important factor in her turning when tacking. In conjunction with her high momentum, due to her heavy ballasting, it enables her to go about very rapidly, the rudder not having time to check her speed. She is reported to have shown herself eight seconds quicker in stays than the Mayflower. Minor features in the rigging of the two vessels are also to be noticed in the different views. The Galatea's masthead spreaders are so wide that they actually cause the topmast shrouds to overhang the hull, being wider than the hull itself. The use of a block and fall on the





ILLUSTRATIONS OF THE AMERICAN YACHT MAYFLOWER.

Galatea's bobstay, necessary with a shifting bowsprit, seems clumsy. Her bowsprit is considerably shorter in proportion to her length than is that of the American vessel. In both vessels, however, the bowsprit is far longer than in American yachts of thirty or forty years ago. In those days, a mast far back and short bowsprit was the rule. This feature is shown very strikingly in old pictures of the Black Maria, the first of our largest size racing sloops.

In the Mayflower, it will be noticed that her bilge is but slightly hollow, very little more than is that of her competitor. Accepting the sloop and cutter subdivisions as of any moment, her model, especially in this feature, indicates an approach of the American sloop to the English cutter.

The theory has long held, and has been justified in practice, that a deep vessel was better in a seaway than a shallow one. There is no question that for rough weather, the old American shallow draught racing boats were defective. The foundering in the Gulf Stream of the Black Maria was a sad proof of this. But having overcome this wrong tendency, the point has been to stop when sufficient depth was reached. There is every probability that this has been done in the Mayflower. A broader vessel plunges less, and having a higher center of gravity rolls less, and careens less under sail, than does a narrow one. In these important respects, as affecting comfort, she is the superior. If it can be shown that this width is not inconsistent with speed, it may be considered that one valuable result has been attained.

The Genesta and Puritan, who competed last year for the international trophy, were somewhat smaller than the present competitors, but were large enough to represent the largest type of single-masted vessels. The general result of recent yachting trials has developed the fact that greater speed is to be looked for from the single-masted vessel than from the schooner. This is, to an extent, unfortunate, as the schooner is far the more practical type. In our river and sound commerce for the last few years, nothing is more striking than the disappearance of sloops and increase in number of schooners. In old times, sloops have been engaged in ocean traffic to a certain extent, but now that rig is being abandoned, except for the smallest class of vessel.

We give the table of dimensions of both vessels below. The interesting features are the relative displacement and lead ballast carried. The Galatea, it will be seen, is really 50 per cent. larger than the Mayflower, and carries nearly twice as much ballast. Yet by the generous N. Y. Y. C. rules she receives a few seconds time allowance from the Mayflower. The exorbitant amount of outside lead ballast and large displacement certainly tend to make her more nearly a racing machine than is her competitor.

	Galatea. ft. in.	Mayflower. ft. in.
Length over all	102 6	100 0
Length on load water line	87 0	85 7
Extreme beam	15 0	23 5
Depth of hold	13 3	8 6
Draught of water	13 5	9 0
Length of mast	79 0	83 0
Length of topmast	47 0	46 0
Bowsprit outboard	36 5	38 0
Main boom	73 0	80 0
Main gaff	45 0	50 0
Spinaker boom	65 5	74 0
Area of sail, per N. Y. Y. C. rule, in square feet	7,146	9,000
Tonnage, O. M.	171 14-95	171 74-95
Displacement, in tons	157·63	110·0
Ballast, in tons	81·50	48·0
Amount on keel, in tons	81·50	42·0

The Galatea is built of steel, and was modeled by Mr. J. Beavor-Webb, a native of Kinsale, County Cork, Ireland. The Mayflower is of wood, and was modeled by Mr. Edward Burgess, of Boston, Mass.

The first race was sailed over the N. Y. Y. C. course. Starting in the Narrows, the yachts sailed down and through the outer bay of New York to and around the lightship that lies about eight miles from the bar, out at sea, a total distance of thirty-eight miles. The Mayflower won by 12 minutes and 2 seconds corrected time; the elapsed time was:

Mayflower	5 h.	26 m.	41 sec.
Galatea	5 h.	38 m.	43 sec.

The second race was sailed on Saturday, September 11, over the outside course upon the ocean, twenty miles out from the lightship at the entrance to New York Bay and back. It was won by the Mayflower by 29 min. 9 sec., corrected time; the elapsed time was:

Mayflower	6 h.	49 m.	00 sec.
Galatea	7 h.	18 m.	48 sec.

The winner of two races out of three takes the cup, subject to future challenge.

AN OLD-TIME FAST SAILER.

To the Editor of the Scientific American:

The interest excited in the contests of the racing yachts reminds me to claim for Baltimore the fastest sailing vessel that ever made a record in this country, and perhaps any other.

More than twenty-five years ago Goodwin & Stevens, of this city, built for the writer a square-rigged vessel, not much larger than the yachts that contested the chief race from New York harbor. This vessel was modeled mostly after the plan of George Steers, noted at that time as something unique. Her chief bearing was slightly forward of the longitudinal center, 23 ft. beam, and not much over 100 ft. long, with about 8 ft. hold, brigantine rig, after the fashion of the English ketch. She was needed and designed as a fast sailer, to do coasting trade on the west coast of Africa. She was very sharp, and in consequence not a large carrier. She left Cape Henry for Cape Palmas, west coast of Africa, with a stiff northwest wind, and her navigator took the risk in departure of a direct line course, with the probability of encountering the persistent calms of what the sailors call the "horse latitudes," about the middle of the Atlantic ocean—a neutralizing point of trade winds and currents. This vessel made the run from Cape Henry, at the mouth of Chesapeake Bay, to Cape Palmas, west coast of Africa, with a full cargo, in twenty-four days. The distance on the arc line varies but little from 5,000 miles. On her travel it was certainly not less, for that line could not be strictly maintained. This is 208 knots in 24 hours for the whole run, or 8¾ knots per hour. About this time a notable passage was made to Liverpool by the packet liner Dreadnought in a fraction less than 14 days, claimed as the quickest ever made. Now, if Land's End is 2,800 miles—which it is not—that ship made 200 miles in 24 hours, or 8⅓ knots per hour during the run. The Dreadnought was beaten by the Mary Atwell 8 knots per day, or equal to one day in the passage of the former vessel, and that in a voyage nearly doubling the distance. It is claimed that this small vessel shows the fastest sailing record extant in crossing an ocean or making a long voyage.

R. H. Atwell.

Baltimore, June 3, 1886.

E. S. CHESBROUGH, C.E.

Ellis Sylvester Chesbrough was born in Baltimore, Maryland, on July 6, 1813; died at Chicago, Aug. 19, 1886. His father was a native of Massachusetts, and being unfortunate in business, had to take his boy from school at the age of thirteen. Ellis became chainman in an engineering party engaged in the preliminary survey of the Baltimore & Ohio Railway. The engineer department was headed by three distinguished men, Stephen H. Long, Jonathan Knight, and William Gibbs McNeill. All the assistants were United States officers, and graduates of West Point. Ellis had only had a few months' public schooling, and of course was behind in education, but the officers, liking him heartily, pushed him on in every way as fast as he could bear it. He must have been a fine boy. Some of the officers even took steps to get for him a cadetship at West Point. The following is a typical incident:

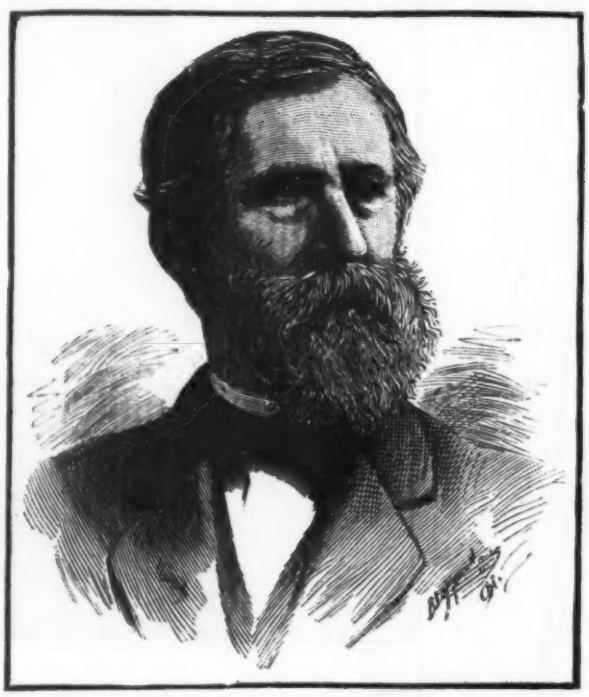
When he was fifteen, he was one of three of a party serving as chainmen. There was wanted, one "man enough to go westward for summer." Lieutenant Joshua Barney, grandson of the famous commodore of 1812, determined that young Chesbrough should go. A man of another party who was passed over said, "He will die before he gets over the mountains." As it happened, he was the only one not discharged, and who did not leave the party before it returned in autumn. He kept on improving himself all along, and at this time devoted himself especially to the study of topography. The second year he was sometimes left in charge of a party.

Being naturally much attached to his military friends, he gladly accepted the offer of Col. Long to make him sub-assistant in the service of the State of Pennsylvania, on the then proposed Allegheny & Portage Railroad. In the summer of 1831 he joined Captain McNeill, then chief engineer of the Paterson & Hudson River Railroad, and under him did a great deal of valuable work. Early in 1837 he was sent to South Carolina as senior assistant of a corps of about seventy engineers, nearly all older than himself. The undertaking was the Louisville, Cincinnati & Charleston Railroad. The following incident at this time occurred. Governor R. Y. Hayne and Major McNeill had a difference. It ended in the latter retiring from the active service of the company. A resident engineer was to be appointed. The governor and major both claimed the right to the appointment. Unknown to each other, they both fixed on the same man—young Chesbrough.

In 1846 he became chief engineer of the western division of the Boston Water Works, and planned the important structure upon it, including the Brookline reservoir. In 1850 he was appointed sole commissioner in the Boston Water Department, and in 1851 city engineer, having charge of all the water works under the Cochituate Water Board, besides the surveyor of the streets and harbor improvements. This position he held until October, 1855. He then became engineer for the Chicago Board of Sewerage Commissioners, and planned the sewerage system of the city. In their interest he visited Europe for information. He was appointed chief engineer when the Board of Public Works was organized. In the winter of 1856–57 he again visited Europe, and became acquainted with the sewerage systems of London, Liverpool, Paris, etc. His report, published in 1858, is highly valued. The river tunnels were planned by him, and were to him a source of much anxiety. He was sneeringly likened to Brunel, but his schemes proved successful.

Mr. Chesbrough was corresponding member of the American Institute of Architects, and Past President of the American Society of Civil Engineers. He was city engineer of Chicago during the continuance of the Board of Public Works, and in 1879 was appointed to the new office of Commissioner of Public Works. He resigned official connection with the city in the spring of that year.

Mr. Chesbrough was connected with a great many important projects which have not been mentioned. He did much good work as consulting engineer. He was consulted on water questions by New York, Boston, Cambridge (Mass.), Toronto, Detroit, and Memphis; on sewage questions by Boston, Providence, Milwaukee, Memphis, Peoria (Ill.), Dubuque, Des Moines and Burlington (Iowa), and Chattanooga (Tenn.); as to tunneling by New York; and by Baltimore as to the overflow of Jones Falls and other subjects. On December 23, 1837, Mr. Chesbrough married Elizabeth Anne Freyer. His widow and two sons survive him.—*Building Budget.*



E. S. CHESBROUGH, C.E.

PRINTING INK PHOTOGRAPHS.

Lichtdruck.—In no country is the process of lichtdruck (collotype) printing worked to such perfection as in Germany. In common with most of the methods of permanent printing, the lichtdruck process is indebted to the discovery of Mungo Ponton of the sensibility to light of bichromate of potassium when combined with organic substances. For the benefit of those unacquainted with the working of this process, I will give it.

A sheet of glass, about a quarter of an inch thick, is the material used for the printing block. This glass plate, after being thoroughly cleaned, is ready to receive the preliminary coating of:

Soluble glass	6½ parts.
White of eggs	20 "
Water	36 "

This solution is always made fresh about an hour or so before using. Care must be taken that the soluble glass does not contain caustic potash. After having been filtered, this mixture is applied to the glass as evenly as possible. This operation is done in a warm room, and the film is very soon dry, when it is thoroughly rinsed with water. This film is exceedingly thin, and will be observed to bear an open, porous, and slightly opalescent surface. The next operation is the coating of the plate with a bichromated gelatine solution, the formula mostly in use being the following:

Bichromate of potash	15 grains.
Gelatine	2½ ounces.
Water	22 "

The plate having been placed on a leveling stand, the warm bichromate gelatine solution is poured on, and when set, is placed in the drying chamber. It is well known that in any process of photographic engraving in half tones it is absolutely necessary to produce what is termed a "grain," so as to obtain an ink holding surface, and giving detail in the shadows. To do this, the uniform photographic gradation must be broken up into a series of points, dots, or other small masses. In the lichtdruck process this broken surface is obtained by the manner in which it is dried, which should on no account take longer than three hours. The drying chamber is usually kept at a temperature of about 55 deg. C. The object is to obtain this already mentioned fine grain over the whole surface of the printing block, and unless this grain is satisfactory the film is of no use whatever. Should the film be too thick, then the grain will be of a coarse nature; or, should the temperature in drying be too high, no grain at all will be obtained. When the film has a fine even grain extending over the whole surface, it can be considered fit for use, and is ready for printing upon. In printing, a stripped negative is generally used, so as

to insure perfect contact all over; where fine detail exists, this is absolutely necessary. If a glass negative be used, it is necessary that it should be upon patent plate glass, as the sensitive film is itself upon a thick glass plate. The exposure is, of course, very rapid. The only way of measuring it is by experience and a photometer After being taken from the printing frame, the plate is placed in a dish containing cold water, for the purpose of thoroughly eliminating the soluble bichromate. About an hour's washing is generally sufficient to do this. It is then taken out and dried. When dry, the plate has the appearance of a design ground on polished glass.

Next comes the etching process. The plate is placed upon a leveling stand, and the following etching fluid poured over it:

Glycerine	300	parts.
Ammonia	100	"
Nitrate of potash	10	"
Water	50	"

This etching fluid is allowed to remain upon the surface of the image for about half an hour, when it is poured off, and a piece of blotting paper placed over the whole, so as to absorb any of the superfluous etching fluid that may be upon the surface. This etching is only resorted to when the block is to be printed from by machinery (schnellpress). When it is to be more carefully handled in a hand press, it is moistened only with a little glycerine and water. By this means the printing block becomes thoroughly impregnated with glycerine and water. After etching, and without washing, the block goes straight to the printing press. The printing is done both by hand and by machinery. In cases where a large quantity of prints are required, the schnellpress (quick press) is used. This press is very similar to the ordinary lithographic press, and is usually worked by a small gas engine. Each press requires about a half horse power. The manipulations are generally carried out by two persons—usually a girl and a skilled mechanic. A man who has been accustomed to lithographic work is the best for this purpose. It requires, as we know, a practiced and skilled hand to produce a good lithographic print, but in the collotype process, where a gelatine printing block is used instead of a stone one, as may be imagined, practice and skill are still more necessary. The only way to obtain good prints from a block is by coaxing judiciously with roller and sponge; but no amount of theoretical teaching will make a good printer. When in the machine, the plate lies upon a large steel bed. This bed, with the glass block, moves horizontally to and fro, and in so doing passes under about a dozen ink rollers, some of leather and some of glue, which not only apply the ink to the gelatine plate, but disperse it; the surface of the block being touched by every one as it passes underneath. Whenever the printing block passes from underneath, immediately an inked slab takes its place, and imparts more color to the rollers. The duty of the man is to see that the ink is applied regularly to the printing block, and in sufficient quantity. The girl's duty is to stand at some height above the machine, and place the sheets of paper around the huge cylinder, which, in revolving, presses against the block, and in this manner receives an impression upon it. It is necessary for the printer to stop the press every few minutes in order to damp the block. This is done with glycerine and water, by means of a small sponge. Before again resuming work, a leather roller is passed over, in order to remove all superfluous moisture; and the block is once more ready for printing from. In order to see how skillful the printer must be, one has only to watch the number of useless proofs that are at first obtained, and to see how gradually improvement takes place by dint of cleaning, rubbing, rolling, etching, etc. In many establishments two kinds of ink are used—*i. e.*, a dark ink and a light one—for producing the half tones; but it is quite possible to secure delicate and vigorous impressions by employing one ink and the two already mentioned kinds of rollers. About one to two thousand impressions can be taken off in a day with these quick presses, but they are obviously not quite so fine as those which can be produced by a careful printer with a hand press. These hand presses, which are known under the name of Stern or Star press, are used mostly for printing of negatives from nature, rather than for copies of pictures or engravings, for which the machine press is the most useful. They are nothing more than the ordinary lithographic hand press, one man being sufficient to work it.

Lichtdruck prints, especially portraits, are usually varnished, but are first coated with a dilute solution of gelatine to act as a sizing, to prevent the varnish from soaking into the paper. This varnish, composed of a solution of shellac or spirit, is generally applied with a broad camel's hair brush, and dried quickly. Some prints are made upon thick paper (these are usually for book illustrations, and are ready for binding without further treatment); others are printed upon fine tone paper, known as "Kreide" paper, varnished and pressed, in order to impart a highly glossy surface. Prints so treated are often sold as silver prints, to which, indeed, they bear a great resemblance. A lichtdruck printer will furnish you with five hundred copies of your carte portrait for 25 marks, or the same number of shillings; for a thousand copies £2 is demanded, cabinets, £3. The prints you get for this price are only made upon ordinary paper; for better paper and glazing, 30 per cent. more is charged. The printing of such things as pictures for catalogues offers a wider field than for portraits; as for the latter, not only must the negative be suitable, but the object also. Merchants and tradesmen are beginning to find out the immense value of photographic illustrations for advertising, and no mechanical process renders greater service in enabling them to place before the public, at a comparatively small cost, correct representations of objects for sale in a most novel and satisfactory manner.

In the last number of the *Photographische Correspondenz*, a handsome colored lichtdruck was sent as a supplement. These colored lichtdrucks are at present mostly made with the aid of draughtsmen and retouchers. The process, as executed by Lowe of Vienna, is about the best, and approaches nearest to that of a genuine photographic picture. A number of printing blocks are made, according to the number of colors to be used. The negative is first stopped out by retouching, leaving open only those parts which are intended to print blue, for instance. A plate is made from it, and in a similar manner it is again retouched for yellow, etc. The colored picture obtained by this means lacks softness, but this softness is finally obtained by printing over the colors from an ordinary lichtdruck plate in half tones, thereby giving the picture its finish. The only book published upon this process is that admirable and useful little treatise, "Das Lichtdruck und die Photo-Lithographie," written by Dr. Julius Schnauss, and published by Liesegang, of Dusseldorf.

Meeting of the Berlin Society.—The last meeting of the Berlin Society for the Advancement of Photography was held on the 9th of July last, President Dr. H. W. Vogel. Herr Richard Weber, of Leipsic, exhibited a set of his new photographic apparatus, specially constructed for wheel riders. The apparatus received universal approbation, and appears cheap at £3 5s. Herr Stenglein then produced a number of micro-photographs, among which were some highly interesting organisms—for example, the comma bacillus. The exhibitor offered explanations of his methods of taking and mounting mineralogical and other photographs. Especially he dwelt at length and with considerable emphasis on the micro-photographs of different classes of bacteria, the study of which has attained such importance within the last few years. Herr Stenglein hopes very soon to have still more perfect specimens of these minute germs. At present he recommends a process of coloring the objects, and particularly the use of aniline dyes. Herr Schultz-Hencke was of opinion that photography could not reproduce such objects with the exactitude of the microscope, and suggested a means of retouching which Herr Stenglein announced he had already taken into consideration. The president displayed several lightning photographs by Feldmann, in Bockenheim, near Frankfort on the Main. Some of these created great interest, particularly one in which the electric fluid appeared to have retraced its own course from its apparent starting point. Herr Goedicke related his experiences of iron and pyrogallic developers, and exhibited his sensitometer plates. Herr Stenglein believed that one developer was not to be preferred to the other. A general discussion then took place as to the relative merits of the developers, in which Dr. Zenker said he preferred the English landscapes to the German, and he believed solely owing to the influence of the pyrogallic development; and Herr Jahr stated that in America the pyrogallic developer was almost exclusively in use. Herr Miethe then read a report of the recent experiments made by Herr Wallroth in portrait taking by the magnesium light. The experiments were conducted in the studio of Herr Halerlandt, and partly at the suggestion of Prof. Vogel. Besides the gentlemen already named, Herr Gadicke and Herr Goety, of New York, were present. Some portraits were almost as well lighted and executed as if taken by day, and particular stress was laid in the report upon the cheapness of the magnesium light, which cost only a trifle under twopence for these experiments. But, on the whole, the trials were not considered decisive, and further communications are promised to the club on the subject. A short discussion followed the reading of Herr Miethe's report, in the course of which the president promised to reproduce the sample pictures exhibited, and to issue them as a supplement to the number of the *Photographische Mittheilungen* for September 1. The president showed also two photographs by Obernetter of the same landscape, one taken upon an ordinary plate, the other upon a color sensitive plate. The difference was very striking; not only was the relative value of the colors more correctly represented on the sensitive plate, but many details were perfectly clear and distinct, which in the picture from the ordinary plate were altogether wanting. Herr Schultz-Hencke and Herr C. Quidde (secretary to the club) exhibited photographs, which were received with great applause; and Herr Comod Stapelfeld, of Frankenberg, contributed to the club for its forthcoming excursion a most excellently planned map with portraits, for which a vote of thanks was granted him. The next ordinary meeting of the club was postponed to the 17th of September, on account of the holidays, but interim meetings will take place on the first and third Fridays in each month at Schaper's establishment, No. 136 Leipsic Street.

THERE are seven paper mills in India—three in Bombay, two in Bengal, and two in the Province of Oudh. The native grasses, roots, and jute waste constitute the principal materials used, and occasionally rags. India's population is 240,000,000.

APPARATUS FOR MEASURING THE COMPRESSIBILITY OF GASES AT A HIGH PRESSURE.

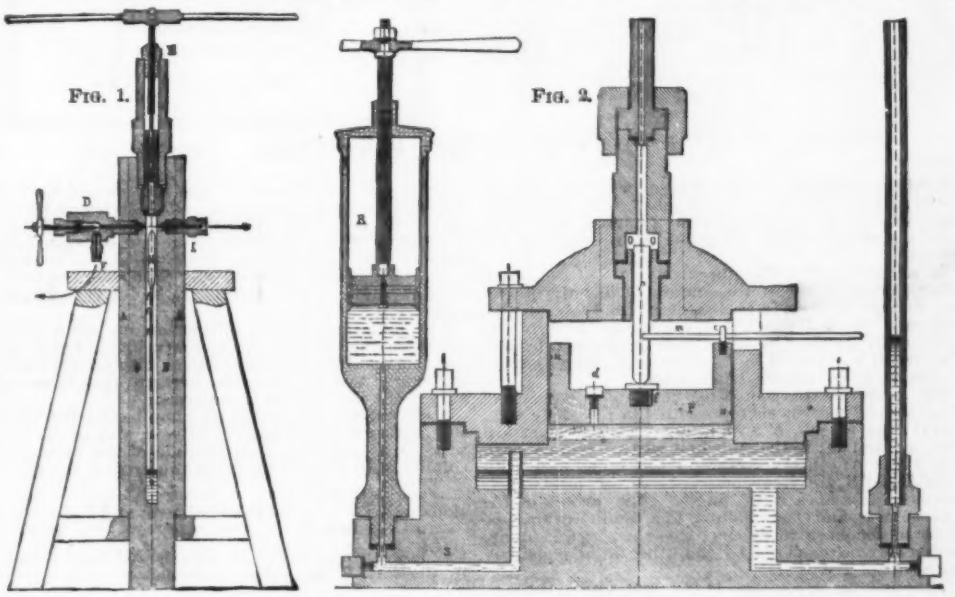
THE accompanying engravings show the arrangement of the apparatus adopted by Mr. Amagat for measuring the compressibility of gases under a high pressure.

The compressing apparatus consists of a cast steel cylinder, B B, surrounded by a strong jacket, A A, which extends a little below the central bar of the cylinder. This central chamber contains a piezometer or a pressure gauge, inclosing the gas or liquid to be studied. In Fig. 1, a piezometer, H H, for liquids is shown.

Pressure is exerted by means of a force pump, which injects glycerine through the tube, E, of a screw plug, D. When, according to circumstances, a pressure of 200, 300, or 600 atmospheres has been reached, the orifice of the screw plug is closed, and the pressure is continued by revolving the central screw, E, by means of a long lever. It is easy to see how this screw drives before it a steel cylinder adjusted with slight friction, which in turn, but without revolving, drives before it a leather capsule.

The piezometer, H, containing the liquid to be tested, dips into mercury, which rises in the tube, since the volume of the liquid diminishes through the effect of the pressure. This tube is provided with several platinum wires, which are connected with each other by an insulated conductor, that establishes a resistance of 2 ohms between each of them. On a level with the screw plug, D, the cylinder is provided with an insulating ring, through which the conductor makes its exit from the cylinder, to run to a properly arranged electric apparatus (two rheostats, a differential galvanometer, or other device), and then return and come into contact with the metal of the apparatus and the mercury. Owing to this arrangement, it is possible to ascertain the exact moment that the mercury touches each of the platinum wires, and to thus obtain the measurement of the volume of the liquid or gas.

The pressure gauge shown in Fig. 2 is a changed and improved Desgoffe apparatus. It communicates with the compressing apparatus through a thimble, I, and a solid steel tube ten feet in length. This pressure



FIGS. 1 AND 2.—APPARATUS FOR MEASURING THE COMPRESSION OF LIQUIDS AND GASES.

gauge is provided with differential pistons, which are entirely free, and have no leather packing, and which are adjusted so as to move with slight friction. The smaller one, *p*, which supports high pressures, is rendered tight by an ingenious artifice, that is, by carefully lubricating it and pouring in molasses at *o*. In this way the piston, while preserving its mobility, is rendered absolutely tight. As for the large piston, P, which is provided with channels to facilitate lubrication, this is rendered tight without interfering with its mobility by causing it to rest upon a stratum of castor oil floating upon a mixture of water and glycerine resting upon mercury. It should be remarked that this piston supports pressures of but a few atmospheres only, say the height of the column of mercury in the tube, T.

The rod, *m*, introduced between two pins, *e*, serves to give the two pistons a simultaneous rotary motion. Such a maneuver is indispensable in order to give the pressure gauge perfect sensitiveness by annulling the feeble resistance that might be produced by imperfectly destroyed minimum frictions through a tangential motion.

Mr. Amagat has found that the indications of this instrument leave nothing to be desired. To this effect he has verified it by comparison with a free column of mercury, and with pressure gauges for nitrogen gas, the law of compressibility of which he has directly determined up to 430 atmospheres.

It remains to be said that the pump, R (seen at the left of Fig. 2), serves to regulate the quantity of liquid necessary to keep the large piston within the desired limits of its stroke. This latter should be short enough to prevent too great a lengthening of that of the small piston, which supports all the stress. At *f* is seen a steel bolt, against the head of which abuts a plunger, *p*, and at *d* an orifice which is usually closed by a screw, and which is designed to allow the air to escape while the piston is rising. It is of interest to add that the piston, *p*, can be removed at will, and be replaced by duplicate pieces of various diameters.

In the apparatus shown herewith, the ratio of the surfaces is such that the mercury rises 6½ feet at T at a pressure of 1,500 atmospheres. As the column of mercury in Mr. Amagat's laboratory is not less than 16 feet in height, it has been found possible to exceed the enormous pressure of 3,000 atmospheres there, while no inequality could be detected in the operation

of the apparatus. Up to the present, the apparatus in use have served scarcely for anything else than preliminary experiments; but Mr. Amagat has already been able to study the compressibility of water and ether, which decreases more quickly than would be imagined. Thus the coefficient of the compressibility of water has been reduced one-half, and that of ether one-third. Aside from its use in studies of a high scientific interest, this pressure gauge may be usefully applied in the industries for measuring very high pressures.—*Revue Industrielle.*

REGISTERING BAROMETERS AND THERMOMETERS.

WE describe in this article a number of these instruments. For them we are indebted to the following journals: *Revista di Artiglieria e Genio*, *Zeitschrift fur Instrumentenkunde*, and the *Revista Scientifico-Industriale.*

REDIER'S REGISTERING BAROMETER.

In the Redier apparatus, a mercurial siphon barometer is employed, J K, Figs. 1 and 4; it is supported by a tablet, M N P Q, which runs between guides and can move in a vertical direction. Counterpoising

FIG. 2.

FIG. 1.

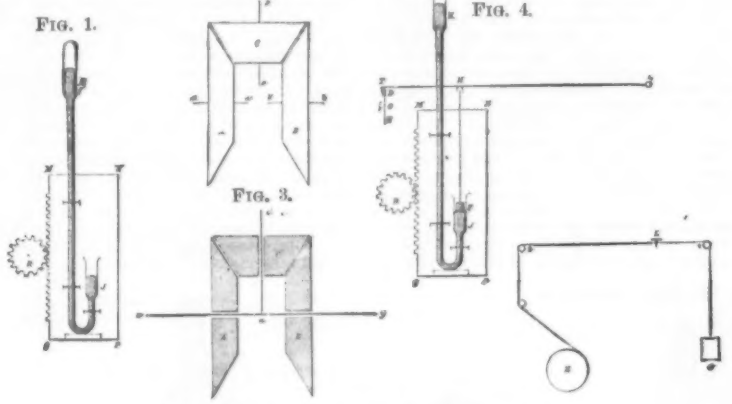


FIG. 4.

FIG. 3.

REDIER'S REGISTERING BAROMETER.

weights are arranged in equilibrium with the weight of the tablet. The tablet is supplied with a vertical rack, M Q, which, engaging with a pinion, R, rises or falls according to the direction of rotation of the pinion.

In an ordinary siphon barometer, when the atmospheric pressure varies, the column of mercury moves and changes its level in both arms of the tube; in this apparatus we shall see that the absolute level of the mercury in the short or open tube remains constant. This result is obtained by a mechanism controlling the pinion, R, to be described immediately.

The principal part of this mechanism consists of three conical cog-wheels represented in Fig. 3, by A, B, and C; the wheels, A and B, have their geometrical axes, aa' and bb', in the same line, and are symmetrical. The third wheel, C, engages at the same time with both A and B, and its geometrical axis, cc', meets their common axis at a right angle. The arbors of the wheels, A, B, and C, are hollow, Fig. 3, and are traversed by solid concentric arbors; these last, xy and uz, are immovably fastened one to the other at u, constituting a sort of T.

The driving arbor, xy, is the one which, through intermediate gearing, controls the cogwheel, R, and thereby it is that the movement of the tablet of the barometer depends on that of this arbor, xy. The wheel, A, by means of properly arranged clockwork, continuously rotates with angular velocity, v, and always in the same direction, which we may term positive.

Let us suppose, for a moment, that the wheel, B, remains fixed; the wheel, A, will transmit its movement to C, which in its turn engages with B; the arm, uz, will begin to move, and will impart to the arbor, xy, a rotation in the positive direction, with velocity, w. But the wheel, B, does not remain always motionless, because it is also controlled by clockwork, which is intermittent instead of continuous. As often as the clockwork ceases to act, the wheel, B, remains fixed, to commence moving again as soon as the action of the clockwork recommences. The movement of rotation of the wheel, B, is in the opposite direction, which we shall term *retrograde* or *negative* (an opposite direction of rotation to that of the wheel, A); the angular velocity in absolute value is $2v$, or double that of the wheel, A. We have already seen that when the wheel, A, moves, it engages only with C, which in its turn puts the wheel, B, in motion, and with the wheel, C, the arm, uz, moves, rotating the arbor, xy, with an angular velocity, w, positive in direction. When both wheels, A and B, turn together, the wheel, C, engaging with both of them, is unequally acted upon; the wheel, A, turns positively with angular velocity, v; the wheel, B, with negative velocity, $2v$; it follows that the resultant effect on the wheel, C, is the same as if the wheel, B, rotated with velocity, v, in negative direction, turning the arbor, xy, in the same direction with a velocity, w. Thus the arbor xy, always turns with a velocity, w, a rotation which is positive if the wheel, A, alone turns, that is when B is not acted on by its own clockwork; and again in the opposite or negative sense when both wheels, A and B, rotate together.

We now may study the method by which intermittent rotation by clockwork of the wheel, B, is produced. In the first place the driving arbor, xy, that controls the pinion, R, raises the tablet of the barometer when it turns in the positive direction, and causes it to descend when it turns in the negative direction. The arrest (Fig. 4) consists of a fly vane, or escapement with wings mounted on one of the arbors of the clockwork acting on the wheel, B. This fly is composed of two arms, O D, O E, carrying two little wings D, E. These two arms are attached to the arbor, O, which forms part of the clockwork acting on the wheel, B, and would always rotate in the direction indicated by the arrow, were it not arrested by an extremely light lever, I T (Fig. 4), free to move around the point, I, and provided with a tooth, T, that catches one or the other of the wings of the fly, D O E. When this arrest of motion takes place we know that the driving arbor, $x\,y$, turns in the positive direction and the tablet of the barometer descends.

This ascensional movement of the tablet would continue indefinitely were it not for a float, F, resting on the surface of the mercury in the short arm of the siphon. This float is provided with an extremely light needle, whose upper end enters a cavity or cup, H, attached to the lever, I T. In the ascencional movement of the barometer tablet the float raises quickly the lever, I T, and so sets free the vane, D O E. The arbor, $x\,y$, then begins to rotate negatively and causes the tablet to descend, until the fly, D O E, is again arrested. Then the tablet begins to ascend, and so on indefinitely. The lever, I T, executes thus without interruption a series of very limited oscillations on either side of its mean position. This mean position corresponds to the period when the lever is ready either to release or arrest the fly, D O E. In like manner the float, F, performs numerous and slight oscillations above and below its mean position.

Practically on account of the lightness of the lever, I T, and the vane, D O E, and the delicacy and perfection of the construction of the clockwork, these oscillations of the float are imperceptible and, so to say, microscopic. The float may, practically speaking, be considered as fixed, and, as has already been said, the level of the mercury in the open tube as absolutely constant in space.

The variations of level of the mercury being without effect on the level of the mercury in the outer tube, become manifest in the vertical displacement of the barometer tablet; when the pressure rises it ascends, and in the reverse case it descends.

It is well known that in a siphon barometer, calling the diameter of the smaller tube, d, and of the larger tube, D, a variation, e, in altitude of the barometeric column is divided between the two arms in the proportions of $h \times \frac{D^2}{D^2+d^2}$ for the small arm and $h \times \frac{d^2}{D^2+d^2}$ for the large arm. Hence it follows that for a variation in pressure, h, the tablet is displaced by the quantity

$$h \times \frac{d^2}{D^2+d^2}.$$

It now remains to be seen how the displacement of the tablet due to a rotation of the pinion R, is transmitted to the registering apparatus. A pulley, S (Fig. 4) is so arranged that its axis is controlled by the cogwheel, R, by means of an accelerating or multiplying train of gear wheels. At a point in the groove of the pulley is attached a thread that passes over pulleys, 1, 2, 3, to which is attached a weight, G, to keep it tight. At one point, L, of this thread is attached a port crayon which bears against a sheet of cardboard moved at a uniform rate of translation in a direction normal to the thread. The movements of the pencil, caused by the thread, will evidently be proportional to the variations in barometeric pressure, because they represent the displacements of the movable tablet, magnified to a greater or less extent by the multiplying train of wheels. Availing ourselves of this latter feature of construction, the graphic representation of variations of pressure by the curve traced by the pencil, L, can be rendered as large as desired.

MAGNETO REGISTERING BAROMETER.

Another type of barometer which seems to have given good results is shown above. The mercury is contained in a siphon tube, similar to that of the Redier barometer, in whose open arm a very light float is placed, that acts on a lever, F (Fig. 5), by means of a waxed silk thread. The lever, F, is made of sugar-cane, weighs 2 grammes, and is 550 millimeters long; it can oscillate around the axis, a (Fig. 6), formed of a very fine steel wire, which passes through it at right angles to its length, and rests in two glass rings of very small size, T (Fig. 6), attached to two extremities of a horse-shoe magnet, A. The magnet is intended to support the greater part of the weight of the lever, F, and in consequence to reduce to the minimum the friction of the axis, a, on its glass bearing, T (Fig. 6). The magnet is sustained between two pieces of wood, P, fastened to the tablet so that it can be moved from below, upward, backward, and forward, as may be required in regulating the apparatus.

The lever, F, is traversed in its anterior part by a very fine wire, S (Fig. 8), freely movable within a fine glass tube, t, and which bears against the surface of a cylinder driven by clockwork. To insure a good contact between the extremities of the wire and the surface of the cylinder, the wire is attached to the end of a filament of straw, R (Figs. 7 and 8), whose other extremity bears against the regulating lever, and which constitutes a flexible spring.

The lever terminates at its posterior end in a circular arc, a (Fig. 7), to which is attached the thread that carries the float, which arc serves not only to maintain the thread in a vertical position, for all changes of the float, but also acts to counterpoise the weight of the anterior part of the lever. To start the apparatus it is only necessary to adjust the weight of the float, f, so that the lever can move from above to below with the greatest facility in all possible positions, and it will be necessary to reduce to a minimum the attrition between the different pieces for the apparatus to attain the greatest sensibility.

The registration is effected on a cylinder, C Y (Fig. 5).

FIG. 5.

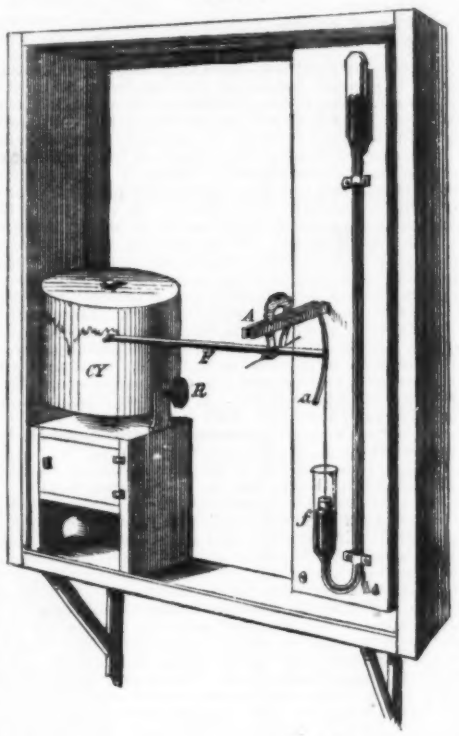


FIG. 7.

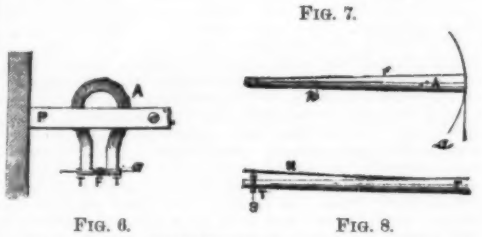


FIG. 6. FIG. 8.

MAGNETO REGISTERING BAROMETER.

which turns once in seven days; its diameter is 213·3 millimeters and its height 300 millimeters. Around this cylinder a sheet of paper is wrapped, that is smoked and covered with lamp-black. When the pressure curve has been traced on it, the image is fixed by immersion in a bath of weak alcoholic solution of resin. The graduations of the scale are obtained by comparison, marking on the curve at fixed periods, the absolute barometric height taken from a standard barometer, by which a comparative base line is traced once for all from a point, R, at the base of the cylinder.

THE THERMOBAROGRAPH.

The "Thermobarograph" is so called because it registers both barometric heights and thermometric degrees. Its different parts are so arranged that the variations in the air thermometer, due to changes of atmospheric pressure, are compensated for automatically. Its characteristic feature consists in suspending

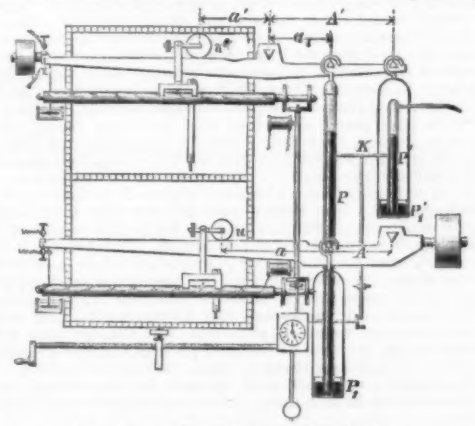


FIG. 9.—THERMOBAROGRAPH.

from the scale beam that carries the manometer a barometer tube; the atmospheric changes of pressure that cause changes in the manometer are compensated for by corresponding variations in the barometer. Again, the scale beams are so arranged that they maintain almost exactly their horizontal position; thus the barometer and other balanced parts hang from points constant and fixed.

Referring to Fig. 9, which gives a general view of the essential parts, it will be understood that the fixed cylindrical glass tube, P', whose upper end connects by a leaden tube with the nitrogen reservoir of the gas thermometer, is carried by a stationary frame not shown in the drawing. The lower open end of this tube dips into a mercury cistern of iron, being immersed in the mercury contained therein. This cistern hangs upon a knife edge on the upper scale beam. Thus, when the temperature rises, the gas in the thermometer (nitrogen) expands; the mercury sinks in the tube, rises in the cistern, and makes it heavier. By the mechanism yet to be described the rider wheel, *u'*, runs back exactly far enough to compensate for this increase of weight, and its new position being registered by well-known means on a graduated sheet of paper, gives the registry of temperature. On the same scale beam a barometer tube is suspended. If the atmospheric pressure diminishes, this increases the weight of mercury in the cistern of the tube, P', but such diminishing of atmospheric pressure also diminishes the weight of mercury in the barometer tube. Hence, by properly locating the points of suspension of the cistern and barometer tube, the latter may be made to automatically correct the errors due to change in barometric altitude.

The barometer cistern hangs from the lower scale beam. By precisely similar means the rider wheel, on its scale beam, is made to keep this cistern counterpoised. As the weight of mercury in the cistern varies with the changes in the barometric column, the movements of the wheel, as registered, give a record of barometric changes.

To start the mercury into motion, a hammer, K, is worked by clockwork, and every two minutes it strikes against the tubes. This will remind our readers of the preliminary slight blow or jar that is given to a barometer before reading it in ordinary practice.

The exact counterpoising by the movements of the wheels is thus secured. Under each scale beam a cylinder is rotated by clockwork. Its surface contains a spiral groove. A projecting piece of the wheel carriage enters this groove. Thus if the cylinder is turned in one direction the wheel moves outward, from the fulcrum of the beam. As in the preceding case, we will call this positive rotation. Then the opposite, or negative rotation, will move the wheel toward the fulcrum. From the clock shown near the base of the apparatus a vertical rod rises, that carries two horizontal fixed gear wheels. Each axis of the helix cylinders carries two vertical wheels. The horizontal clock wheels gear with one or the other of these wheels, as the vertical axis is moved to the right or left. The movements toward the left are given it by electro-magnets. When released it springs back to the right, engaging with the left hand or right hand horizontal wheel, according to its own position. At the end of the scale beams will be seen contact points. When the weight of the mercury hanging on one of the scale beams preponderates, that scale beam makes a contact and the positive rotation of its cylinder is secured by the horizontal wheel being drawn to the left, so as to engage with the left hand vertical wheel. This carries the rider wheel outward until it overbalances, when the contact is broken, and the reverse, or negative, rotation begins, the right hand horizontal wheel engaging with the vertical wheel, and this action on an infinitesimal scale may be supposed for each scale beam to be indefinitely repeated.

Thus the beams are kept horizontal, and the movements of the compensating pulleys being registered by known means, the barometer and thermometer readings are continuously recorded. In Figs. 10 and 11, details of

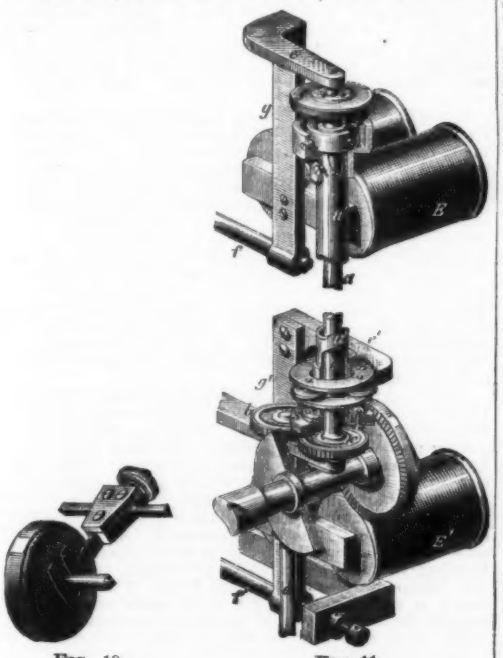


FIG. 10. FIG. 11.

DETAILS OF THERMOBAROGRAPH.

construction of the rider wheels and magnets and gear wheels are given. Enough has been said to make their construction clear. The wheels have circumferential grooves, which work over corresponding projections, or tongues, on top of the scale beam. This guides the wheels, and prevents them from leaving the beam or running sidewise.

ARTIMINI'S THERMOPYROMETER.

The registering thermopyrometer (Fig. 12) of Prof. Filippo Artimini is given as an example of an extremely simple instrument that can be made to act with considerable accuracy. The articulated rods form two rectangular spirals, if such an expression can be allowed. They are carefully jointed with each other at the corners. Besides this, the horizontal ones are pivoted at a point nearer or further from the center, according to the desired delicacy. The instrument works by the expansion and contraction of the vertical rods, and by altering the position of the fixed pivots the delicacy can be increased or diminished. The rack and pinion movement actuating the central axis that carries the needle is so clear as to need little or no explanation. Loose pivoted rollers are provided to hold the rack and pinion engaged. To make it self-registering, the little pallets

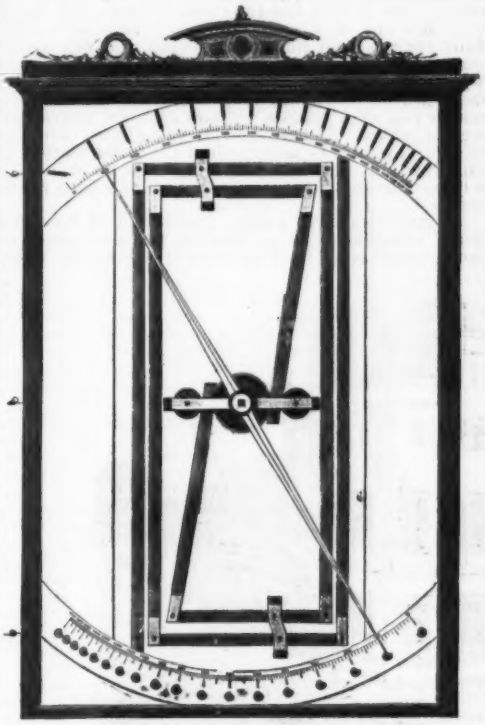


FIG. 12.—REGISTERING THERMOPYROMETER OF PROF. FILIPPO ARTIMINI.

that are turned by the movements of the index are provided, or they may be used as electrical contact points. The apparatus has to be graduated by comparison by heating to known temperatures.

MORELAND'S REGISTERING BAROMETER.

The principle on which the Moreland barometer depends is in brief the following: The apparatus shown in outline in the cut consists of a mercurial barometer tube, B, which at *a*, near its base, is provided with an air trap. This is suspended at *b* to the three-armed scale beam, *b c d e*, and its lower end dips into the mercury cistern, F. Below *a* the tube carries the plate, D, which protects the mercury in F from dust. Every change in the height of the barometric column changes the weight of the barometric tube and contents, and causes a change in position of the scale beam and of the light index, *f*, attached thereto.

In order that this movement of the scale-beam and index may take place on a large enough scale, the barometer tube at its upper end is enlarged, so as to have an internal diameter of about 30 mm. The amplification of the movement of the index, *f*, can be regulated by the position of the weights, P and *q*, on the arms, *c d* and *c e*. The nearer these are brought to the

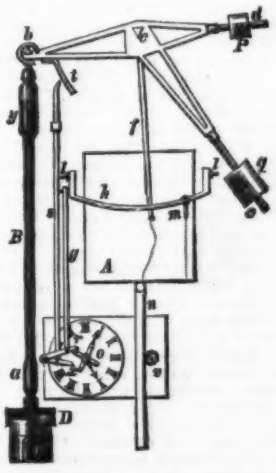


FIG. 13.—MORELAND'S REGISTERING BAROMETER.

point of suspension, *c*, of the beam, the greater will be the amplitude of the movements of the index, *f*. Commonly the amplitude of the movement of the index is so adjusted that a change of 1 mm. in the barometric column moves the index about 2 mm. The points of the arms on which the weights, P and *q*, should be placed are shown by a line cut in the metal. To the lower end of the index, *f*, is attached either a metallic stylus or a small wheel supplied with printer's ink.

The registration is effected by the aid of a clock, which carries four arms on its minute arbor. Each of these arms raises once in a revolution of the minute hand the lever arm, *r*, and this, by the rod, *g*, also raises the pivoted piece, *h*. On the completion of each quarter of an hour, the lever, *r*, drops from one of the arms, *o*, and causes the piece, *h*, to fall, and thus drive the stylus or wheel on the index, *f*, against the paper, A. If it is a wheel that is attached to the index, *f*, a small piece of leather smeared with printers' ink lies under it, over which the wheel, at each lifting of the piece, *h*, is drawn by means of a hook attached thereto, and thus is newly inked for each impression. On *h* also is found a metallic stylus, *m*, which, as the paper, A, is drawn under it, regulated by the toothed bar, *n*, and the wheel, *v*, driven by the clock, marks the zero line.

To overcome the adhesion of the mercury to the glass tube, the following method is adopted: A second shorter lever arm, *x*, lying back of the arm, *r*, is also raised up by the arms, *a*, on the minute hand arbor. The rod, *s*, is connected with the same, which, when it is raised, catches on the toothed sector, *t*, and raises the whole barometer. About ten minutes before the next registration, the arm *x* falls from the arm *o*, and the barometer tube drops suddenly into its former position, or rather oscillates near it, until it again comes to rest a few minutes before the next registration. By the movement of the mercury thus brought about within the barometer tube, the adhesion is destroyed. By slightly bending the upper end of the rod, *s*, one way or the other, the displacement of the barometer can be made greater or smaller.

For reduction of the registrations obtained with this barometer, a special ruled or divided glass plate is supplied, whose first vertical division corresponds with the zero line. The divisions of the glass plate are so arranged that the movements of the index follow a division of radius equal to its length. Hence the readings give millimeters directly.

According to the principle of the angular balance, an equally large movement of the index will express in all cases a given change in weight of the barometer, so that the ordinates marked on the paper must be in direct proportion to the change of height of barometer. When the height of barometer has once been found that corresponds to a given registration of the apparatus on the axis of abscissas, and the relation has also been found that the ordinates bear to given changes in the height of mercurial barometers, the apparatus will give absolute barometric heights. Then if the barometer is of enlarged diameter at its top, the apparatus must have a considerable coefficient of correction for temperature, and as the correction for the constant of the individual instrument, and the fixing of the correction for temperature, have to be combined, the estimation of final constants for reduction of this barograph is somewhat difficult.

WEAVING SCHOOL AT MULHEIM.

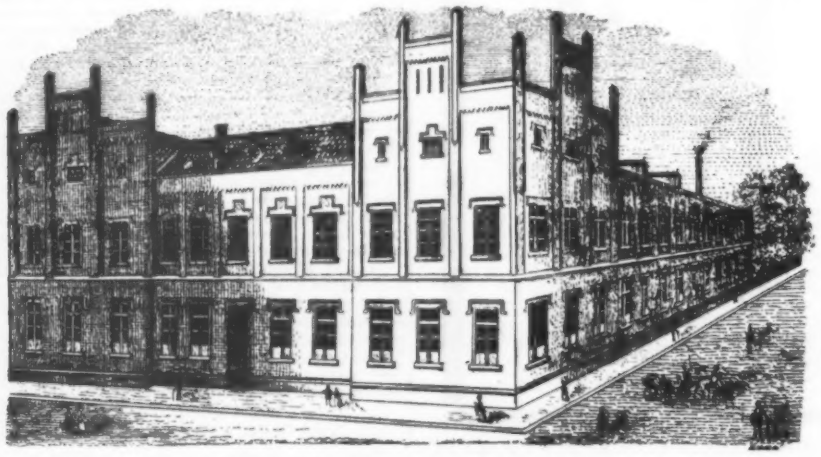
THE considerable progress made by Germany during recent years in textile manufactures is generally attributed to the superior system of technical education in that country, and there can be no doubt that it is one co-operating cause of the great extension of manufacturing industry, though others, such as the reduction in the prices of coal, play, no doubt, an equally important part. Among the technical schools, the weaving schools of Germany have probably exerted most influence on the progress in the textile industries, and have always received considerable support, not only from manufacturers, but also from the municipalities and the Government. The oldest of these schools in Germany, and probably in Europe, is the Higher Weaving School at Mulheim on the Rhine (of which we give an illustration), whose annual report we have just received; and as the subject of technical education continues to receive much attention in this country, we think it will interest most of our readers to receive some information about a Continental institution that has undoubtedly been successful in its work.

Founded in 1852, the school has steadily increased in size and importance, and even during the last five years, when several new schools—that at Crefeld, for instance—entered into a competition, the attendance has grown. It has trained from its commencement above 1,700 day students; during the last year 113 persons attended, of whom nearly one-third were foreigners, among them three sons of prominent manufacturers of Lyons and Paris. The expenses not covered by the fees are paid in equal parts by the town and the Prussian Government. There are four teachers, including the head master, for theoretical instruction, and the same number of foremen for practical exercises. The instruction comprises theory and practice of weaving, designing, draughting patterns, etc., calculating yarns and cloths and their cost, theory and practice of dyeing, chemical and microscopical examination of materials. Besides these, there is a general course of lectures on raw materials and spinning, and on motive power engines, and opportunities are afforded to learn shorthand and bookkeeping. The main feature of the instruction, however, is that, with the exception of a few lectures on general subjects, it is given individually and specially. For instance, in composing and decomposing patterns, one such pattern is not treated before the whole class, but each student provides himself with such as specially interest him, and everything connected with them is explained to him separately, and he afterward reproduces them on the loom. Thus persons interested in velveteens, for instance, can devote themselves, if they choose, exclusively to this material in all its branches, and need not join in any lectures or exercises on silk or Jacquard weaving. Undoubtedly in this way a much more thorough knowledge of the special branch which will occupy the student in after life can be obtained in a comparatively short time than if every one received a superficial instruction in every branch of the very extended field of weaving. The school possesses spacious buildings, as will be seen from the illustration, with extensive collections of raw and finished materials, dyestuff, etc., a complete dyeing establishment, and 32 treadle and Jacquard hand looms and 18 power looms for tweeds, coatings, linen, damask, silk, velvet, ribbons, etc.

There are some points to which it may be useful to draw the attention of the managers of similar establishments recently started in this country. One is the large teaching staff, which is of course necessitated by the system of individual instruction, but certainly largely exceeds that of English institutions, being one teacher to every dozen scholars. The other point is that the school does not profess to educate artisans as such, but managers, manufacturers, and buyers and salesmen. There has been a great deal written about the necessity of giving technical instruction to our

workmen, if we are not to be outrun in the race of competition, but it is not they who most need it. In the present subdivision of labor, the special work done by each person in a factory can be acquired without any technical knowledge at all, nor does it require much intelligence, but rather manual dexterity. We of course cordially approve that facilities should be afforded to intelligent young men of the working classes to obtain technical instruction to enable them to rise to the position of foremen or masters, or other places of trust. But this statement shows by itself that it is not as artisans they require such instruction, but for other posts, and we venture to say that in England it is not the men who require more extended technical teaching so much as the masters, to enable them to adapt themselves more readily to the continually changing conditions of the markets than they do at present.

Another point is the large educational plant owned by the school, amounting to about one loom for every two scholars, so that each of them can be employed in the practical work of taking down and erecting, tying up, drawing in, and weaving, for rather more than half the time, some scholars being employed in dyeing, beaming, etc. This of course is the result of the length of time the school has been in existence, and cannot be expected in the newly founded schools in England, but we would suggest to our loom makers that if they



WEAVING SCHOOL AT MULHEIM.

wish to give any donations to our technical schools, it cannot take a better form than a loom of the most modern construction.—*Textile Manufacturer.*

EXAMINATION IN CHEMISTRY.

THE new editor of the "Science and Art Directory," says *Nature*, announces a new departure of the most important kind in the teaching of chemistry. In addition to the oral instruction in the elementary stage, there is now introduced an alternative first stage or elementary course, intended for those students who only require the elements of chemistry as a foundation for their studies in other subjects.

We give the new syllabus, so that it may speak for itself, and congratulate the department on a step in harmony with the views of the best friends of scientific education in this country.

SOLUTION.—Disappearance of a solid in a liquid by solution. Saturation of a liquid. Effect of increase of temperature on saturation. Effect of lowering the temperature on saturation. Crystallization. Filtration. Solvent properties of water. Rain, spring, river, and pond waters, etc. Solid matter in different waters; how estimated. Loch Katrine water. Thames water. Sea water. Hard and soft waters. Mineral waters. Similar solvent of other liquids. Solution of one liquid in another. Liquids insoluble in one another. Solution of gases in water and other liquids. The effect of heat on the quantity of gas dissolved by a liquid.

Experiments.—Suspend a piece of white sugar by a thread in a glass vessel containing water. Dissolve salt in water. Show on a balance that sugar or salt and water when separate and when dissolved weigh the same. Show that salt is obtained from the solution by evaporation. Saturate water with niter, and show that the solubility is increased by increase of temperature. Demonstrate the formation of crystals. Illustrate the removal of substances in suspension, and the non-removal of substances in solution by filtration. Show by evaporation the solid matter dissolved in a sample of pump, or river, or spring water, and explain the method for its quantitative determination. Show the like solvent action with other liquids, as calcium chloride, in alcohol and sulphur in carbon disulphide. Compare the result of admixture of spirit or oil of vitriol with water with that of oil or mercury with water. Heat ordinary water and collect the expelled air.

AIR.—Surrounds the globe. Wind is air in motion. Breathing. Air occupies space. The bulk of any quantity of air is much changed by temperature and by pressure. Air has weight. The necessity of air for animals and plants. Bodies when burning require air. Air a mixture of two gases. Oxygen and nitrogen. The proportion of nitrogen to oxygen. Oxygen the active body in air. Bodies burn in it alone and more brilliantly than in air. The combination of oxygen with iron and with other bodies. Increase of weight of bodies which unite with oxygen. Nitrogen does not combine directly with bodies. The nearly constant composition of pure air. Presence of other gases in small amount in air. Water in the air as a gas. The drying up of water.

Experiments.—That air occupies space may be shown by plunging a bell jar into a vessel of water. Fit a flask containing water with an India-rubber plug and delivery tube, heat the water, and collect the expelled air over water. Close the short limb of a siphon tube containing air, and compress the air in the long limb by pouring in mercury. Weigh a flask, fitted with a stop-cock, full of air, and then exhaust by an air-pump, and weigh again. Show that a lighted candle is soon extinguished when burnt under a bell jar, but that it continues to burn if fresh air be from time to time supplied. Burn phosphorus in a tall bell jar over water, and show the diminution of bulk of air. Ignite phosphorus, place it in the remaining gas. Burn some phosphorus under a dry bell jar to show the compound of phosphorus and oxygen which is formed. Place phosphorus in a graduated tube over water to show that at ordinary temperatures it combines with the oxygen of the air and removes it, so that by measuring the volume of gas left, the amount of oxygen contained in air can be roughly determined. (To introduce the phosphorus, fuse it in a test-tube under water, and introduce the end of a long wire into it, then let it cool). Burn charcoal and sulphur in oxygen, and call attention to their disappearance. Demonstrate by lime water and by litmus paper that a new body is in each case formed. Burn iron powder (*Ferrum vidactum*) on a scale pan of a balance, to show that an increase of weight occurs. A glass or metal vessel filled with ice or cold water can be used to show the condensation of mixture upon it. Place calcium chloride on the pan of a balance to show the gradual increase of weight which occurs.

WATER.—Its three states. Expansion of water by heat. Equal volumes at different temperatures have not the same weight. Formation of currents in water by heating. Boiling point. Increase of volume on conversion of water into steam. Distillation. Pure water. Hydrogen and its properties The burning of hydrogen in air, and the weight of the product compared with the weight of the hydrogen; the difference due to oxygen of the air with which hydrogen has combined. Hence oxygen and hydrogen are the constituents of water. Combination of oxygen and hydrogen with explosion to form water. If by measure there be twice as much hydrogen as oxygen, or by weight eight times as much oxygen as hydrogen, then no gas remains—all becomes water. All water composed of these two bodies in this proportion. These two bodies can then be separated from water and can be made to make, unite, and form water. In all cases of chemical combination, bodies are united in constant proportion.

Experiments.—Illustrate the characteristic properties of ice, water, and steam. Show that equal volumes of hot and cold water do not counterbalance one another. Fill a flask to the bottom of the neck with cold water, and then heat to show expansion of the water. Show current by heating a large flask of water. To illustrate distillation, distill water containing copper sulphate. Show Liebig's or other forms of condensers. Show the mode of determining the boiling point of a liquid. Show that the temperature remains constant, and that on dissolving substances in water the boiling point is raised To show the presence of hydrogen in water, pass steam through a red-hot iron tube filled with coarse iron turnings or nails. Water formed of two components, both gaseous. Note the change in the iron both in appearance and weight. This increase of weight and the weight of gas which comes off equals weight of steam which has disappeared. Hence two substances in water, one the combustible gas that comes through the tube, the other the body which remains with the iron. Collect the hydrogen over cold water in proof that it is not steam, also show that it burns. After the tube is cooled show the iron from inside of the tube and explode the oxygen and hydrogen. Plunge a burning taper into jar of hydrogen held mouth downward, to show burning of the gas and extinction of the taper. Show by a balloon, or soap bubbles, or inverted beaker glass suspended from a balance, that hydrogen is lighter than air. Condense the water formed by the burning of a jet of hydrogen.

CARBON.—Charcoal, graphite, or black lead and diamond. When wood, sugar, meat, bread, are heated, carbon remains. Charcoal not changed in the air at ordinary temperatures. Combination of carbon with the oxygen of the air at a red heat. Carbon dioxide a compound of carbon and oxygen. Chemical combination of carbon and oxygen is attended by the evolution of a definite amount of heat expressed by amount of water it will heat. Combustion. The properties of carbon dioxide. Water dissolves carbon dioxide at ordinary temperatures. Action of carbon dioxide on lime water; no animal can live in this gas. 100 parts of carbon dioxide are composed of 27·27 parts of carbon, and 72·73 parts of oxygen. Carbon dioxide obtained from marble, limestone, oyster-shells, chalk, etc. Charcoal fire. Coal composed of carbon, hydrogen, and a little oxygen, etc.; its burning is the carbon and the hydrogen combining with oxygen. Whenever oil, tallow, coal gas, are burnt, this carbon dioxide and oxide of hydrogen (water) are formed. Respiration produces similar changes. In expired air the same products arise as from the burning of the food, and there is the same evolution of heat. Carbon a constituent of all animal and vegetable bodies.

Experiments.—Specimens of charcoal. Make charcoal by heating wood in covered crucible. The black lead of a pencil as a specimen of graphite. Sugar heated on piece of tin plate. Show that acids and alkalies do not change charcoal, but that when heated it soon burns away, and only ash is left. Take a small piece of charcoal in a glass tube, pass air over it into lime water, and show no change takes place until the charcoal is made red hot; as the charcoal disappears the lime water becomes milky. Show by means of the balance, or by soap bubbles, or by passing it from one vessel to another, that carbon dioxide is heavier than air, that it acts on lime water, that a burning candle is extinguished in it. Its solubility in water shown by agitating a tube of the gas over water. Prepare the gas from marble by the action on it of dilute acid. Collect all the gas given off from a small piece of marble weighing 5 or 10 grains. Show by collecting in inverted beaker the products of combustion of a candle, of a lamp, and of a gas flame, and adding lime water, that carbon dioxide is given off. Show also by means of lime water that respired air contains this gas.

SULPHUR.—Known also as brimstone. Where found. Its properties. Is also found chemically combined with many metals, so not recognizable by the eye. Sulphur heated in the air melts; more strongly heated it burns, then the sulphur disappears; the strong smell produced belongs to a new body formed by the burning, a compound of sulphur and oxygen. Gaseous properties of the new body, its effect on blue litmus paper, which oxygen and sulphur have not. Its composition is 50·00 parts of sulphur and 50·00 parts of oxygen, and it is called sulphur dioxide. Water dissolves nearly fifty times its volume of this gas, and then turns blue litmus strongly red and has an acid taste. The combination of the gas and water to form sulphurous acid. Another compound of sulphur and oxygen can be made, in which the same weight of sulphur is combined with more oxygen. One hundred parts contain 40 of sulphur and 60 of oxygen, and it is called sulphur trioxide. Sulphur trioxide has properties differing from the dioxide. If the dioxide and oxygen be mixed they do not combine, but if they are passed over hot platinum dense white fumes are formed, which are the trioxide. Combination of the trioxide with water to form sulphuric acid (oil of vitriol).

Experiments.—Show roll and flowers of sulphur and specimen of native sulphur, also iron pyrites and other native sulphides. Powder iron pyrites and heat it in a tube held horizontally over a lamp to show the sulphur obtained from the pyrites. Show the melting of sulphur by heating flowers of sulphur in small flask. Heat sulphur on a piece of tin plate till it catches fire, show the color of the flame and observe the smell of burning sulphur. Prepare sulphur dioxide by heating copper turnings in sulphuric acid, and show that it extinguishes flame, is very soluble in water, and that the water dissolving it becomes very acid, turning blue litmus red. Bubble air through a strong solution of sulphur dioxide, and then over platinized asbestos; demonstrate that when the platinized asbestos is hot, dense white fumes are formed of the sulphur trioxide. Pour some sulphuric acid into 20 or 30 times its volume of water and prove its acid taste, its action on litmus, and its power of causing effervescence if dropped on sodium carbonate. Show that sulphuric acid is a colorless liquid, that, bulk for bulk, it is much heavier, more than 1¾ times, than water. Show by a thermometer or by immersing a test tube with spirit in it that a large amount of heat is evolved when this acid is poured into water. Pour some on sugar or shake it up with oil to show its action on organic bodies.

CHLORINE.—The gas obtained by the action of hydrochloric acid on the black oxide of manganese. So called on account of its color. Its characteristic smell. Is 2½ times heavier than air and 35½ times heavier than hydrogen. Soluble in water. Many substances take fire in chlorine gas, *e. g.*, phosphorus, and form chlorides. Ignition of oil of turpentine in chlorine with separation of carbon and formation of hydrochloric acid. Bleaching power of chlorine. Bleaching powder.

Experiments.—Samples of common salt, rock salt. Prepare chlorine from (1) mixture of common salt, black oxide of manganese, and sulphuric acid; (2) from mixture of black oxide of manganese and hydrochloric acid. Collect gas by downward displacement. Draw attention to its color, and show that phosphorus spontaneously inflames in the gas to form chemical compound of phosphorus and chlorine. Show that oil of turpentine ignites spontaneously in chlorine. Show that sodium when strongly heated burns in chlorine and forms common salt. Show bleaching action of chlorine by dipping moistened Turkey red rag in bottle filled with gas. Show similar action with solution of bleaching powder and acid. Show that chlorine is soluble in water and that the solution has characteristic smell and color of the gas.

ACIDS.—Are bodies which have sour taste, turn blue litmus red, and liberate carbon dioxide when added to solution of sodium carbonate. Sulphuric acid has these properties. Its specific gravity. Colorless when pure. Evolves heat on being mixed with water. There are two other common bodies which have strong acid properties like sulphuric acid, these are nitric acid and hydrochloric or muriatic acid; these are made of different constituents from sulphuric acid. All act on litmus, etc., in same way; all can be neutralized by potash forming potassium sulphate, or nitrate, or chloride. The compound formed by the union of an acid and alkali is called a salt. All three acids are colorless liquids, but, besides the properties possessed by all acids, each acid has properties which belong to it alone. Nitric acid attacks most metals. Poured on copper, the metal is dissolved and red fumes are formed. Hydrochloric acid does not dissolve copper, is not so heavy as sulphuric acid; when mixed with manganese dioxide, gives off a yellow irrespirable gas known as chlorine.

Experiments.—Samples of both nitric and hydrochloric acid. Show that they have all the properties belonging to acids, and that by neutralizing them common salt and niter can be made. Show the action of nitric acid on copper, tin foil, etc. Show that it has no action on platinum or on gold. Copper placed in hydrochloric acid not attacked, but if mixed with manganese dioxide and warmed, chlorine is given off.

ALKALIES.—Are another class of bodies which turn red litmus blue; have soapy taste and absorb carbon dioxide. If potash be added gradually to sulphuric acid the properties of both bodies gradually disappear, and at last a liquid is obtained that has no action on

litmus. The combination of acid and alkali and the body formation of sulphate of potash or potassium sulphate; sulphate of soda or sulphate of ammonia can be formed in a similar manner.

Experiments.—Show that solutions of potash, soda, and ammonia turn reddened litmus blue, and that when a tube containing carbon dioxide is inverted in any of these solutions the gas is absorbed. The taste of these bodies is soapy, not sour. Add gradually to dilute sulphuric acid one of these bodies, and see that the acid character of the dilute sulphuric acid disappears. Neutralize exactly sulphuric acid with potash, then evaporate and crystallize out the salt formed.

AMMONIA.—A gas with a very pungent smell. Solution in water. One volume of water dissolves 800 volumes of ammonia. This liquid has the pungent smell of the gas, and it can neutralize the strongest acids. Formation of ammonium chloride or sal ammoniac by ammonia with hydrochloric acid. Ammonium chloride a white solid, soluble in water, with no smell of ammonia. Ammonium chloride a volatile body. The effect of boiling a solution of ammonium chloride with lime or potash. Ammonia is composed of 82·3 parts of nitrogen and 17·7 parts of hydrogen. The pungent odor of smelling salts is due to ammonia. Animal matters, such as horn, dried flesh, glue, cheese, isinglass, heated so as to decompose these bodies, yield ammonia. The formation of ammonia in large quantities by heating coal to make coal gas. Production of ammonia when animal matters containing nitrogen putrefy.

Experiments.—Prepare ammonia by treating ammonium chloride with an equal weight of slaked lime and enough water to make the whole into a thick mud; and demonstrate its smell, its action on red litmus, and its great solubility in water. The gas passed into water, the increase of volume of the liquid. Its properties and their identity with those of the gas. Volatility of ammonia shown by the liquid leaving no residue on evaporation Show that ammonium chloride is formed by neutralizing a solution of ammonia with hydrochloric acid, and is obtained as a solid on evaporation, and that on further heating it is volatilized. Heat coal in a coarse powder in a glass tube, and show that the liquid obtained is very alkaline. Show the formation of ammonia by the addition of potash and lime to a solution of ammonium chloride.

LIME AND CLAY.—Limestone, marble, oyster shells, chalk, all contain a metal known as calcium. The oxide of this metal known as lime. Lime and carbon dioxide are together present in limestone, marble, shells, and chalk. When these are strongly heated, especially in a current of air, the carbon dioxide is evolved and the lime is left. Action of water on lime. Its use in making mortar. Lime slightly soluble in water. On blowing carbon dioxide into a clear solution of lime (lime water), liquid becomes turbid, owing to combination of carbon dioxide and lime to form chalk. Same effect on breathing through lime water. Other important salts of lime are gypsum or plaster of Paris (sulphate of lime) and phosphate of lime, which exists largely in bone. Clay is a combination of a body called silica, which is the chief constituent of sand and flint, with the oxide of a metal known as aluminum, so called because it exists also in alum. Glass is a compound of silica with lime and an alkali, potash or soda. Varieties of clay; their use in manufacture of bricks and pots. The metal of clay (aluminum), a white body with a brilliant luster, 2½ times heavier than water; may be rolled out into thin sheets and drawn into fine wire. Not oxidized in the air.

Experiments.—Samples of limestone, marble, oyster shells. Show that these substances effervesce with dilute hydrochloric acid, and that a gas carbon dioxide is evolved. Heat a piece of limestone or marble to redness in a fire, and show that, after heating, it no longer gives off carbon dioxide on treatment with an acid. Describe process of lime burning. Properties of lime as distinguished from limestone. Show that a piece of moistened red litmus paper pressed against limestone is not affected, but that when pressed against lime it is turned blue. Show slaking of lime; draw attention to heat evolved. No such result on treating limestone with water. Show that lime is soluble in water, whereas limestone is not. Add carbon dioxide to the solution of lime, and show that white powder is formed, which, on treatment with acid, evolves carbon dioxide again. Explain that white powder thus formed is identical in chemical composition with limestone, and hence that limestone is a compound of carbon dioxide and lime. Explain use of lime in making mortar. Various samples of clay are used in manufacture of bricks and pots. Show plasticity of clay and exhibit one or two specimens of ware before being baked. Show that a vessel of kneaded or "puddled" clay will hold water. Explain chemical nature of clay, and show specimens of silica and alumina. Show alum and demonstrate that alumina is contained in it by heating ammonia alum. Show specimen of aluminum and explain that this metal is contained in alumina and therefore in clay.

METALS. INTRODUCTORY.—About 70 different elementary subjects known. Almost all the common metals are elements. For instance, iron, lead, copper, zinc, mercury, silver, gold, tin, are elements. All combine with oxygen to form oxides, with chlorine to form chlorides, and with sulphur to form sulphides.

Experiment.—Specimens of metallic and non-metallic elements and of oxides and sulphides.

LEAD.—Its color; a fresh surface bright, but soon tarnishes in the air. Is heavy. Lead is 11½ times heavier than water. Can be beaten or rolled into thin sheet or drawn into wire. Melts at temperature 633° F. Can be cast in a mould. Its combination when liquid with oxygen. Formation of lead oxide. The oxide has entirely different properties from lead. Removal of the oxygen when heated with carbon and the formation of metallic lead. Formation of red lead by heating the oxide. Solution of lead by nitric acid and the formation of lead nitrate. Solution of lead oxide by nitric acid and the formation of lead nitrate. Similarly to potassium nitrate, this is to be termed "a salt." Its solution in water. Other salts of lead, chloride, sulphate. Formation of sulphate and chloride of lead, their insolubility in water. Galena, or lead sulphide, one of the ores from which lead is obtained.

Experiments.—Piece of lead to scrape and show it is then bright and has "metallic" appearance. Show by balance that compared with water it is, bulk for bulk, much heavier. Show the metal beaten out into thin sheet, also as wire. Melt lead in an iron spoon, and cast in a mould. Show formation of oxide by blowing air on to the melted metal. Contrast the properties of the oxide with those of the metal. Convert the oxide again into metal by strongly heating an intimate mixture of it and charcoal powder. Heat the oxide to show its further oxidation and the formation of red lead. Show the action of nitric acid on lead, also on lead oxide, and the formation of lead nitrate. Show this is "salt," and prove that it is soluble in water. Demonstrate that the first is very slightly soluble, and the last almost insoluble in water. Show the formation of chloride and sulphate of lead by the addition of the respective acids to a solution of lead nitrate. Collect on filter the salts so formed, wash and dry them. Show specimen of galena (lead sulphide).

IRON.—Not used in a pure condition, always obtained united with carbon. Three kinds of iron—wrought iron, cast iron, and steel. Wrought iron the purest and used if the body is to be formed by hammering. Cast iron contains most carbon. Steel used for cutting instruments: can be made into a magnet; can be "annealed." Solubility of all three forms of iron in sulphuric, nitric, and in hydrochloric acids, and the formation of iron sulphate, nitrate, and chloride. Their solubility in water. Melting point of iron is at much higher temperature than that of lead. Comparison of the weight of iron with that of water. Its color. The ready action of air on it. Formation of rust. Oxidation by heating. The action of steam on iron when red hot. Oxide of iron heated with hydrogen or with carbon parts with its oxygen, and iron is left. Oxide of iron found in the earth. Hematite. A carbonate of iron mixed with clay used as a source of iron. Heating the ore, the iron is converted into oxide. Removal of the oxygen by heating it to a very high temperature with carbon. Formation of slag from clay and lime.

Experiments.—Specimens of the different kinds of iron—wrought iron, cast iron, and steel. Dissolve cast iron in hydrochloric acid diluted with equal volume of water, show carbon which remains, filter and evaporate the liquid to show the chloride of iron formed. Heat iron wire by the blowpipe to show the high temperature required to fuse it. Iron acted on by air and moisture to show its rusting. Heat iron oxide in a tube and pass hydrogen over it to show formation of water and metallic iron. Show specimens of iron ores, clay iron stone Hematite magnetic iron ore, and slag.

COPPER.—Its color. Does not rust in air at ordinary temperatures. Thin wire melts in flame of Bunsen burner. When heated in air becomes black, owing to formation of an oxide. Oxide heated in hydrogen gas yields up its oxygen, water is formed, and the red colored copper is obtained. Action of acids on copper. With dilute nitric acid evolves a colorless gas, which turns red in contact with the air, and the metal dissolves, forming a green solution of copper nitrate. Heated with sulphuric acid, copper yields sulphur dioxide, the same gas which is formed when sulphur burns in air or in oxygen. Substance formed when copper dissolved in sulphuric acid is, when crystallized from water, of a fine blue color, known as copper sulphate or blue vitriol. Action of vegetable acids on copper. Verdigris. Use of copper in alloys. A penny composed of 95 parts of copper, 4 parts of tin, and 1 part of zinc Bell metal and gun metal contain copper and tin.

Experiments.—Show specimens of copper in bar, sheet, and wire. Point out characteristic color of metal. Heat piece of sheet copper over flame of Bunsen burner. Show formation of black film. Explain its origin. Take black oxide of copper and heat in hydrogen gas. Show that metal is again formed and that water is produced. Show action of nitric and sulphuric acids upon copper. Exhibit specimen of copper sulphate (blue vitriol). Show that on placing a knife blade in a solution of copper sulphate, metallic copper is formed on the steel. Show sample of verdigris and explain how formed. Show various alloys of copper, bell metal; brass, gun metal, etc., a penny piece.

MERCURY.—A liquid metal, but if it be cooled to —40° Fahrenheit it is solid. Its metallic appearance. Its weight; heaviest liquid known; 13·6 times heavier than water. Use in the barometer and thermometer. Does not rust or tarnish in the air at ordinary temperatures, oxidation if heated to about 600° F. in the air, and the formation of red mercuric oxide. Is readily attacked and dissolved by nitric acid. It dissolves many metals,—*e. g.*, tin, lead, etc.; amalgams. Mercury in combination with sulphur, as cinnabar. Mercury can be obtained from any salt of mercury by heat, volatilization of mercury and the condensation of the vapor.

Experiments.—Specimen of mercury. Show that to balance a given volume of mercury 13½ volumes of water are necessary. Boil a little mercury in a tube to show it vaporizes. Treat mercury with nitric acid and show its solution. Show that tin foil is dissolved by mercury, which becomes less fluid. Heat mercuric oxide in a tube and collect both the oxygen and the mercury. Heat mercuric chloride in tube sealed at one end with dry sodium carbonate, and show the metallic mercury condensed on the side of the tube.

SODIUM.—Common salt contains a metal, combined with chlorine, known as sodium. 100 parts of common salt contain 39·3 parts of sodium and 60·7 parts of chlorine. Carbonate of soda (washing soda) contains sodium. Sodium obtained on strongly heating carbonate of soda with charcoal. Sodium one of the lightest solids known. Swims on the surface of water and decomposes that liquid with evolution of hydrogen and formation of the alkali soda. Other properties of the metal sodium: its low fusibility and softness. Its tarnishing in air. Preservation of sodium from action of air by being kept in some liquid lighter than water and free from oxygen.

Experiments.—Samples of common salt and rock salt; also washing soda and bicarbonate of soda. Recall experiment showing that chlorine is constituent of common salt. Show that washing soda and sodium bicarbonate evolve carbon dioxide on treatment with an acid. Common salt a compound of chlorine with a metal called sodium; bicarbonate of soda and washing soda compounds of carbon dioxide and sodium. Sodium can be made by strongly heating sodium carbonate with charcoal. Exhibit specimen of portions sodium. Show that it can be cut with a knife, and that the pieces so cut can be pressed together again. Exhibit metallic luster of sodium; show that it quickly tarnishes in the air. Show that sodium is lighter than water and decomposes that liquid with evolution of gas (hydrogen). Collect hydrogen from water by thrusting small piece of sodium beneath test-tube filled with water and standing in basin of water.

CARBON COMPOUNDS.—Large numbers of substances are met with in plants and animals which are not found in the earth. Most of these bodies contain carbon. The other elements united with the carbon are hydrogen, oxygen, nitrogen; some bodies are composed of all these elements; others of only two of them. Many of these bodies when heated leave black residue of carbon; when this is more strongly heated, it burns away. The great number of these carbon compounds, and the great difference in their properties. Some are acids, *e. g.*, vinegar (acetic acid) and tartaric acid. Some are salts, *e. g.*, fats, tallow, butter. Some are neutral bodies, *e. g.*, sugar, starch, spirit.

Experiment.—Show that on heating any ordinary vegetable or animal substance carbon is left behind.

ACETIC ACID.—One form of dilute acetic acid is known as vinegar. Formation of acetic acid when beer or wine exposed to the air becomes sour. The spirit present combines with oxygen of the air and forms acetic acid. The presence of a kind of fungus called *mycoderma aceti* necessary to cause this oxidation. Large amount of vinegar is made from poor kinds of wine and beer. Action of vinegar on blue litmus and on sodium carbonate. Vinegar is also made by heating wood in a retort; a great many bodies distill over, among them acetic acid. The pure acid has very pungent smell, and has all the properties which are characteristic of the acids. Boils at 246° F. Dissolves in water. It is composed of carbon, hydrogen, and oxygen in the proportion of 40·0 parts of carbon, 6·7 parts of hydrogen, and 53·3 parts of oxygen. It is neutralized by alkalies like sulphuric acid. Iron put into it is slowly dissolved, hydrogen being given off. Oxide of lead dissolves in it, forming a salt, and if the clear solution be evaporated a white crystalline body, called "sugar of lead," is formed, which is lead acetate. The vinegar smell belongs only to the acid, not to the salts. Sodium acetate has no smell; add to it sulphuric acid and warm, when the smell shows the acid has been liberated and that it is volatile

Experiments.—Show that vinegar has the properties of an acid, and that a salt is formed on neutralizing it. Show a specimen of the commercial acetic acid, and point out its colorless appearance and strong smell and acid reaction. Show that iron is acted on and dissolved by acetic acid. Make sugar of lead by dissolving lead oxide in acetic acid, and crystallize out the salt. Point out disappearance of the pungent odor of the acid on neutralization by potash or soda. Demonstrate the liberation of the acid as indicated by the odor on addition of sulphuric acid to sodium acetate, and show that it can be separated from the liquid by distillation.

TARTARIC ACID.—Occurs in many fruits; especially in grapes. Is obtained from "argol," an impure potassium salt of tartaric acid, deposited when grape juice ferments. Tartaric acid is a crystalline solid, and dissolves easily in water. Has no smell. Is composed of carbon, hydrogen, and oxygen, *i. e.*, the same elements as are in acetic acid, but in different proportions, viz., 32·0 parts of carbon, 4·0 parts of hydrogen, and 64·0 parts of oxygen. Its action on sodium carbonate. Effervescing draughts; Seidlitz powders. Tartrates.

Experiments.—Specimen of argol and of crystals of tartaric acid. Show solubility of the solid acid in water, and that the solution has acid properties and is without odor. Demonstrate the presence of carbon in the acid by ignition.

FAT AND OILS.—Are neutral bodies made up of an acid and a base; the base in all cases is glycerine, the acid varies in different oils and fats. They are all insoluble in water. Oils are liquid; fats are solid. Many of the oils are obtained from vegetables, either from the seed or fruit. Most of the fats are from animals. Melting of tallow (fat of the ox, sheep, etc.) put in boiling water. Its non-solution in water. Its lightness as compared with water. If a solution of caustic potash be added, and the solution of the liquid boiled, the fat disappears and the liquid becomes slightly milky, and nearly the whole dissolves. Combination of the potash with the acid (stearic) of the tallow, and formation of potassium stearate. Previously the stearic acid was combined with glycerine. To the solution of potassium stearate hydrochloric acid is added. The potash is again separated from the stearic acid, and the stearic acid, as it cannot dissolve in water, separates out. Stearic acid dissolves in alcohol and in ether and separates out in crystals. Used in making candles, and is better than tallow because it melts at a higher temperature. Tallow distilled with steam of temperature 600° F. (high pressure steam) separates into stearic acid and glycerine and when cold these bodies remain separate. All oils and fats are decomposed by potash in the same way as tallow.

Experiments.—Tie beef or mutton fat up in muslin bag, and melt to separate the fat from membraneous matter. Show that fat is insoluble in water, and that it floats on water, and melts at a temperature below boiling water. Show that oil has very similar properties to melted fat. Boil oil or fat with caustic potash. Prepare a solution of potassium stearate, and precipitate stearic acid from it by the addition of hydrochloric acid. Show the solubility of the acid in alcohol and ether, and the insolubility of the lime salt of stearic acid.

GLYCERINE.—A thick, colorless liquid with a sweet taste. Dissolves readily in water. When quite pure, becomes solid at a low temperature. If heated alone it is destroyed, but if heated with water in a retort it distills over with the steam. Heated with acids it combines with them, and bodies similar to fats are formed.

Experiment.—Specimen of glycerine. Demonstrate its solubility in water and its sweet taste.

SOAP.—By boiling fat with caustic soda, sodium stearate is formed. On adding salt to the liquid, the sodium stearate, which is soap, separates out and solidifies on the surface of the liquid. Softsoap is potassium stearate. Action of soap in washing. Action of soap on hard and on soft waters.

Experiment.—Shake distilled water up in bottle with soap. Show action of solution of salts and acids on the solution. Add soap solution to distilled water, also to common water, and explain the difference of action.

Show the presence of stearic acid in soap by adding hydrochloric acid to a solution of soap.

SUGAR.—Exists in many plants. Is obtained from the sugar cane; also from beet root. The juice of these plants yields the sugar. When pure it is white, crystalline, sweet, and very soluble in water. Sugar candy. If heated with very little water to 365° F., on cooling it is no longer crystalline and is "barley sugar." Does not combine with acids, but even a very little acid boiled for a long time with a solution of sugar changes it to another kind of sugar. Composition of cane sugar. The several different kinds of sugar, *e. g.*, the solid part of honey is a sugar which differs from the sugar in the sugar cane; the same found in all sweet fruits and is called grape sugar. Grape sugar not so sweet nor so soluble as cane sugar.

Experiment.—Specimens of ordinary white and brown sugar; also sugar candy and barley sugar. Show its great solubility in water; also that its solution is neutral. Heat it and point out the peculiar odor it gives out, and that on further continuing the heat it leaves a residue of carbon. Wash honey with spirit, and show the residue is sugar, but that it is not sweet as ordinary sugar, and not so soluble.

STARCH.—A neutral substance, composed of carbon, hydrogen, and oxygen. Composition. Peculiar structure; not crystalline. Is found in all parts of a plant. Is obtained from wheat, rice, potatoes, arrowroot, etc. Starch in its ordinary condition insoluble in water. When starch powder is boiled with water, the membrane of starch cells bursts, and the starch is partially dissolved. Strong solutions form a jelly when cold. Used for stiffening linen. Starch recognized by its forming a blue compound with iodine. Undergoes no change in the air at ordinary temperatures; if heated to about 300° F. it becomes slightly discolored and is changed into a soluble body, known as British gum (dextrin). If small amount of nitric or hydrochloric acid be added to the starch, this change is more rapid. Extract of malt also changes starch into soluble compounds. Starch as a food.

Experiment.—Specimen (of starch), point out its peculiar structure and absence of crystalline form. Demonstrate that it does not dissolve in cold water, but on boiling some does dissolve. Show that starch both solid and in solution gives a blue color when iodine is added to it. Moisten starch with very dilute hydrochloric acid, and heat to convert it into a gum, which is thus soluble in water.

GLUTEN.—If flour is tied up in a calico bag and well kneaded in a basin of water, the water becomes milky, and on standing starch sinks to the bottom. All the starch in the flour can thus be removed, and then a sticky substance remains in the bag, called gluten. About 70 per cent. of flour is starch and 10 per cent. is gluten. Gluten contains nitrogen, starch does not. These bodies represent two most important constituents of food. The gluten exposed to the air soon decomposes and smells very disagreeably (putrefies).

Experiment.—Tie some flour up in a piece of calico and knead it for some time in a vessel of water; the starch comes through, and will settle to the bottom of the vessel, and can be collected and examined; the gluten remains in the bag.

SPIRIT.—Alcohol, spirits of wine. A colorless, light liquid. Neutral to test papers. Has pleasant odor, boils at 173° F. Burns with a flame, which gives very little light, without leaving any black residue of carbon. A large number of different bodies dissolve in it. It is the intoxicating principle in wines and spirits. In beer, there is 3 to 5 per cent. of alcohol. In light wines, about 8 per cent. In spirits, 60 to 75 per cent. The different flavors of wines and spirits depend on very small quantities of other bodies present. Alcohol dissolves in water, giving out heat.

"Proof spirit" contains 50·76 parts of water and 49·24 parts of alcohol. If more water be present, the spirit will not set fire to gunpowder when burning. Alcohol obtained from grape sugar. Fermentation grape sugar converted into alcohol and carbon dioxide by presence of some ferment which exists in yeast. Cane sugar on the addition of yeast is first converted into grape sugar, then into alcohol and carbon dioxide. Use of yeast in brewing. Not necessary for making wine, as there is alrady a ferment in expressed juice of grape.

Experiment.—Show it is neutral liquid dissolving in water, that it burns with nearly colorless flame and leaves no residue of carbon. Show that it can be made to boil at much lower temperature than water by placing test tube of it in hot water. Distill beer, and collect the alcohol and water which comes over; add quick lime to this. Allow it to stand some hours, and distill again. Show that this is much stronger, catches fire readily, and tastes more burning. Make a solution of common sugar in a large flask; add yeast, and fit a cork with a bent tube to the flask. Let the tube dip into lime water. Place it in a warm place, and after some days show that spirit has been formed in the flask by distilling the liquid and collecting the portion coming over first.

All the substances and experiments mentioned above are to be shown to the class. This does not preclude such other experiments and illustrations as may suggest themselves to the teacher.

ETCHED FIGURES AND ARRANGEMENT OF ATOMS.

THE method of "etched figures," which within the past few years has proved so successful in the detection of hemihedral and tetartohedral forms on crystals which appear to be holohedral, bids fair to play some part in the discussion regarding the position of the atoms in the molecules of crystalline substances. When linnæite (Co_3S_4) is treated with acids, its cubic faces are most readily attacked. When treated with fused potash, however, the solution takes place most rapidly in the direction of the dodecahedral planes. This fact leads F. Becke (Tschermak's "Min. und Petrogr. Mitt.," 8, 195) to observe that probably the cobalt atoms in the molecule are turned toward the cubic faces, and the sulphur atoms toward the dodecahedral faces. Whether the use of this method will throw any light on the position of the atoms in space is doubtful. It is probable, however, that it will help to an understanding of the forces which act in the formation of crystals.—*W. S. B., in American Chemical Journal.*

[NATURE.]

CAPILLARY ATTRACTION.

By WILLIAM THOMSON.

THE heaviness of matter had been known for as many thousand years as men and philosophers had lived on the earth, but none had suspected or imagined, before Newton's discovery of universal gravitation, that heaviness is due to action at a distance between two portions of matter. Electrical attractions and repulsions, and magnetic attractions and repulsions, had been familiar to naturalists and philosophers for two or three thousand years. Gilbert, by showing that the earth, acting as a great magnet, is the efficient cause of the compass needle's pointing to the north, had enlarged people's ideas regarding the distances at which magnets can exert sensible action. But neither he nor any one else had suggested that heaviness is the resultant of mutual attractions between all parts of the heavy body and all parts of the earth, and it had not entered the imagination of man to conceive that different portions of matter at the earth's surface, or even the more dignified masses called the heavenly bodies, mutually attract one another.

Newton did not himself give any observational or experimental proof of the mutual attraction between any two bodies, of which both are smaller than the moon. The smallest case of gravitational action which was included in the observational foundation of his theory was that of the moon on the waters of the ocean, by which the tides are produced; but his inductive conclusion that the heaviness of a piece of matter at the earth's surface is the resultant of attractions from all parts of the earth acting in inverse proportion to squares of distances made it highly probable that pieces of matter within a few feet or a few inches attract one another according to the same law of distance, and Cavendish's splendid experiment verified this conclusion. But now for our question of this evening. Does this attraction between any particle of matter in one body and any particle of matter in another continue to vary inversely as the square of the distance, when the distance between the nearest points of the two bodies is diminished to an inch (Cavendish's experiment does not demonstrate this, but makes it very probable), or to a centimeter, or to the hundred thousandth of a centimeter, or to the hundred millionth of a centimeter?

Now I dip my finger into this basin of water; you see proved a force of attraction between the finger and the drop hanging from it, and between the matter on the two sides of any horizontal plane you like to imagine through the hanging water. These forces are millions of times greater than what you would calculate from the Newtonian law, on the supposition that water is perfectly homogeneous. Hence either these forces of attraction must, at very small distances, increase enormously more rapidly than according to the Newtonian law, or the substance of water is not homogeneous. We now all know that it is not homogeneous.

The Newtonian theory of gravitation is not surer to us now than is the atomic or molecular theory in chemistry and physics; so far, at all events, as its assertion of heterogeneousness in the minute structure of matter apparently homogeneous to our senses and to our most delicate direct instrumental tests. Hence, unless we find heterogeneousness and the Newtonian law of attraction incapable of explaining cohesion and capillary attraction, we are not forced to seek the explanation in a deviation from Newton's law of gravitational force. In a little communication to the Royal Society of Edinburgh twenty-four years ago,* I showed that heterogeneousness does suffice to account for any force of cohesion, however great, provided only we give sufficiently great density to the molecules in the heterogeneous structure.

Nothing satisfactory, however, or very interesting mechanically, seems attainable by any attempt to work out this theory without taking into account the molecular motions which we know to be inherent in matter, and to constitute its heat. But so far as the main phenomena of capillary attraction are concerned, it is satisfactory to know that the complete molecular theory could not but lead to the same resultant action in the aggregate as if water and the solids touching it were each utterly homogeneous to infinite minuteness, and were acted on by mutual forces of attraction sufficiently strong between portions of matter which are exceedingly near one another, but utterly insensible between portions of matter at sensible distances. This idea of attraction insensible at sensible distances (whatever molecular view we may learn, or people not now born may learn after us, to account for the innate nature of the action) is indeed the key to the theory of capillary attraction, and it is to Hawksbee† that we owe it. Laplace took it up and thoroughly worked it out mathematically in a very admirable manner. One part of the theory which he left defective—the action of a solid upon a liquid, and the mutual action between two liquids—was made dynamically perfect by Gauss, and the finishing touch to the mathematical theory was given by Neumann in stating for liquids the rule corresponding to Gauss' rule for angles of contact between liquids and solids.

Gauss, expressing enthusiastic appreciation of Laplace's work, adopts the same fundamental assumption of attraction sensible only at insensible distances, and, while proposing as chief object to complete the part of the theory not worked out by his predecessor, treats the dynamical problem afresh in a remarkably improved manner, by founding it wholly upon the principle of what we now call potential energy. Thus, though the formulas in which he expresses mathematically his ideas are scarcely less alarming in appearance than those of Laplace, it is very easy to translate them into words by which the whole theory will be made perfectly intelligible to persons who imagine themselves incapable of understanding sextuple integrals. Let us place ourselves conveniently at the center of the earth, so as not to be disturbed by gravity. Take now two portions of water, and let them be shaped over a certain area of each, call it A for the one, and B for the other, so that when put together they will fit perfectly throughout these areas.

To save all trouble in manipulating the supposed pieces of water, let them become for a time perfectly rigid, without, however, any change in their mutual attraction. Bring them now together till the two surfaces, A and B, come to be within the one-hundred-thousandth of an inch apart, that is, the forty-thousandth of a centimeter, or two hundred and fifty micro-millimeters (about half the wave length of green light). At so great a distance the attraction is quite insensible; we may feel very confident that it differs, by but a small percentage, from the exceedingly small force of attraction which we should calculate for it according to the Newtonian law, on the supposition of perfect uniformity of density in each of the attracting bodies. Well known phenomena of bubbles, and of watery films wetting solids, make it quite certain that the molecular attraction does not become sensible until the distance is much less than 250 micro-millimeters.

From the consideration of such phenomena, Quincke (*Pogg. Ann.*, 1869) came to the conclusion that the molecular attraction does become sensible at distances of about fifty micro-millimeters. His conclusion is strikingly confirmed by the very important discovery of Reinold and Rucker that the black film, always formed before an undisturbed soap bubble breaks, has a uniform or nearly uniform thickness of about eleven or twelve micro-millimeters. The abrupt commencement, and the permanent stability, of the black film demonstrate a proposition of fundamental importance in the molecular theory: The tension of the film, which is sensibly constant when the thickness exceeds fifty micro-millimeters, diminishes to a minimum, and begins to increase again when the thickness is diminished to ten micro-millimeters. It seems not possible to explain this fact by any imaginable law of force between the different portions of the film supposed homogeneous, and we are forced to the conclusion that it depends upon molecular heterogeneousness. When the homogeneous molar theory is thus disproved by observation, and its assumption of a law of attraction augmenting more rapidly than according to the Newtonian law when the distance becomes less than fifty micro-millimeters is proved to be insufficient, may we not go farther and say that it is unnecessary to assume any deviation from the Newtonian law of force varying inversely as the square of the distance continuously from the millionth of a micro-millimeter to the remotest star or remotest piece of matter in the universe; and, until we see how gravity itself is to be explained, as Newton and Faraday thought it must be explained, by some continuous action of intervening or surrounding matter, may we not be temporarily satisfied to explain capillary attraction merely as Newtonian attraction intensified in virtue of intensely dense molecules movable among one another, of which the aggregate constitutes a mass of liquid or solid.

But now for the present, and for the rest of this evening, let us dismiss all idea of molecular theory, and think of the molar theory pure and simple, of Laplace and Gauss. Returning to our two pieces of rigidified water left at a distance of 250 micro-millimeters from one another. Holding them in my two hands, I let them come nearer and nearer until they touch all along the surfaces, A and B. They begin to attract one another with a force which may be scarcely sensible to my hands when their distance apart is fifty micro-millimeters, or even as little as ten micro-millimeters; but which certainly becomes sensible when the distance becomes one micro-millimeter or the fraction of a micro-millimeter; and enormous, hundreds or thousands of kilogrammes weight, before they come into absolute contact. I am supposing the area of each of the opposed surfaces to be a few square centimeters. To fix the ideas, I shall suppose it to be exactly thirty square centimeters. If my sense of force were sufficiently metrical, I should find that the work done by the attraction of the rigidified pieces of water in pulling my two hands together was just about four and a half centimeter-grammes. The force to do this work, if it had been uniform throughout the space of fifty micro-millimeters (five-millionths of a centimeter) must have been nine hundred thousand grammes weight, that is to say, nine-tenths of a ton. But in reality it is done by a force increasing from something very small at the distance of fifty micro-millimeters to some unknown greatest amount. It may reach a maximum before absolute contact, and then begin to diminish, or it may increase and increase up to contact, we cannot tell which. Whatever may be the law of variation of the force, it is certain that throughout a small part of the distance it is considerably more than one ton. It is possible that it is enormously more than one ton, to make up the ascertained amount of work of four and a half centimeter-grammes performed in a space of fifty micro-millimeters.

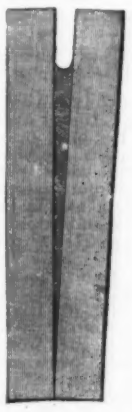


FIG. 1.

But now let us vary the circumstances a little. I take the two pieces of rigidified water, and bring them to touch at a pair of corresponding points in the borders of the two surfaces, A and B, keeping the rest of these surfaces wide asunder (see Fig. 1). The work done on my hands in this proceeding is infinitesimal. Now, without at all altering the law of attractive force, let a minute film of the rigidified water

* Proceedings of the Royal Society of Edinburgh, April 21, 1862 (vol. iv.).

† Royal Society Transactions, 1709-13.

become fluid all over each of the surfaces, A and B; you see exactly what takes place. The pieces of matter I hold in my hands are not the supposed pieces of rigidified water. They are glass, with the surfaces, A and B, thoroughly clean and wetted all over, each with a thin film of water. What you now see taking place is the same as what would take place if things were exactly according to our ideal supposition. Imagine, therefore, that there are really two pieces of water, all rigid, except the thin film on each of the surfaces, A and B, which are to be put together. Remember also that the Royal Institution, in which we are met, has

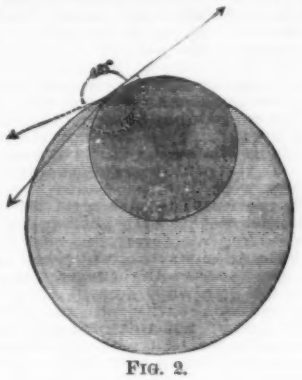


FIG. 2.

been, for the occasion, transported to the center of the earth, so that we are not troubled in any way by gravity. You see we are not troubled by any trickling down of these liquid films—but I must not say *down*, we have no up and down here. You see the liquid film does not trickle along these surfaces toward the table, at least you must imagine that it does not do so. I now turn one or both of these pieces of matter till they are so nearly in contact all over the surfaces, A and B, that the whole interstice becomes filled with water. My metrical sense of touch tells me that exactly four and a half centimeter-grammes of work has again been done; this time, however, not by a very great force through a space of less than fifty micro-millimeters, but by a very gentle force acting throughout the large space of the turning or folding together motion which you have seen, and now see again. We know, in fact, by

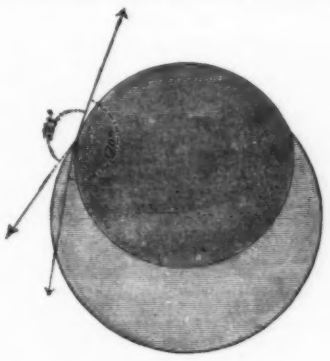


FIG. 3.

the elementary principle of work done in a conservative system, that the work done in the first case of letting the two bodies come together directly, and in the second case of letting them come together by first bringing two points into contact and then folding them together, must be the same, and my metrical sense of touch has merely told me in this particular sense what we all know theoretically must be true in every case of proceeding by different ways to the same end from the same beginning.

Now in this second way we have, in performing the folding motion, allowed the water surface to become less by 60 square centimeters. It is easily seen that, provided the radius of curvature in every part of the surface exceeds one or two hundred times the extent of distance to which the molecular attraction is sensible, or, as we may say practically, provided the radius of curvature is everywhere greater than 5,000 micro-milli-

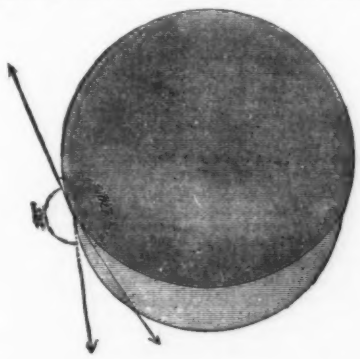


FIG. 4.

meters (that is, the two-hundredth of a millimeter), we should have obtained this amount of work with the same diminution of water surface, however performed. Hence our result is that we have found 4·5·60 (or 3-40) of a centimeter-gramme of work per square centimeter of diminution of surface. This is precisely the result we should have had if the water had been absolutely deprived of the attractive force between water and water, and its whole surface had been coated over with an infinitely thin contractile film possessing a uniform contractile force of 3-40 of a gramme weight, or 75 milligrammes, per lineal centimeter.

It is now convenient to keep to our ideal film, and give up thinking of what, according to our present capacity for imagining molecular action, is the more real thing, namely, the mutual attraction between the different portions of the liquid. But do not, I entreat you, fall into the paradoxical habit of thinking of the surface film as other than an ideal way of stating the resultant effect of mutual attraction between the different portions of the fluid. Look, now, at one of

FIG. 5.

the pieces of water ideally rigidified, or, if you please, at the two pieces put together to make one. Remember we are at the center of the earth. What will take place if this piece of matter resting in the air before you suddenly ceases to be rigid? Imagine it, as I have said, to be inclosed in a film everywhere tending to contract with a force equal to 3-40 of a gramme or 75 milligrammes weight per lineal centimeter. This contractile film will clearly press most where the convexity is greatest. A very elementary piece of mathematics tells us that on the rigid convex surface which you see, the amount of its pressure per square centimeter will be found by multiplying the sum * of the curvatures in two mutually perpendicular normal sections by the amount of the force per lineal centimeter. In any place where the surface is concave the effect of the surface tension is to suck outward—that is to say, in mathematical language, to exert negative pressure inward. Now, suppose in an instant the rigidity to be annulled, and the piece of glass which you see, still undisturbed by gravity, to become water. The instantaneous effect of these unequal pressures over its surface will be to set it in motion. If it were a perfect fluid it would go on vibrating forever with widely irregular vibrations, starting from so rude an initial shape as this which I hold in my hand. Water, as any other liquid, is in reality viscous, and therefore the vibrations will gradually subside, and the piece of matter will come to rest in a spherical figure, slightly warmed as the result of the work done by the forces of mutual attraction by which it was set in motion from the initial shape. The work done by these forces during the change of the body from any one shape to any other is in simple proportion to the diminution of the

FIG. 6.

whole surface area; and the configuration of equilibrium, when there is no disturbance from gravity, or from any other solid or liquid body, is the figure in which the surface area is the smallest possible that can inclose the given bulk of matter.

I have calculated the period of vibration of a sphere of water † (a dew-drop!) and find it to be $\frac{1}{4}\ a^{\frac{3}{2}}$, where a is the radius measured in centimeters; thus—

For a radius of	¼ cm.	the period is	$\frac{1}{12}$ second.
"	1	" "	¼ "
"	2·54	" "	1 "
"	4	" "	2 "
"	16	" "	16 "
"	36	" "	36 "
"	1407	" "	13,200 "

The dynamics of the subject, so far as a single liquid is concerned, is absolutely comprised in the mathematics without symbols which I have put before you. Twenty pages covered with sextuple integrals could tell us no more.

Hitherto we have only considered mutual attraction between the parts of two portions of one and the same liquid—water for instance. Consider, now, two different kinds of liquid; for instance, water and carbon disulphide (which, for brevity, I shall call sulphide). Deal with them exactly as we dealt with the two pieces of water. I need not go through the whole process again; the result is obvious. Thirty times the excess of the sum of the surface-tensions of the two liquids separately, above the tension of the interface between them, is equal to the work done in letting the two

FIG. 7.

bodies come together directly over the supposed area of thirty square centimeters. *Hence the interfacial tension per unit area of the interface is equal to the excess of the sum of the surface tensions of the two liquids separately, above the work done in letting the two bodies come together directly so as to meet in a unit area of each.* In the particular case of two similar bodies coming together into perfect contact, the interfacial tension must be zero, and therefore the work done in letting them come together over a unit area must be exactly equal to twice the surface tension; which is the case we first considered.

If the work done between two different liquids in letting them come together over a small area exceeds the sum of the surface tensions, the interfacial tension is negative. The result is an instantaneous puckering of the interface, as the commencement of diffusion and the well-known process of continued inter-diffusion follows.

Consider next the mutual attraction between a solid and a liquid. Choose any particular area of the solid, and let a portion of the surface of the liquid be preliminarily shaped to fit it. Let now the liquid, kept for the moment rigid, be allowed to come into contact over this area with the solid. The amount by which the work done per unit area of contact falls short of the surface tension of the liquid is equal to the interfacial tension of the liquid. If the work done per unit area is exactly equal to the free-surface tension of the liquid, the interfacial tension is zero. In this case the surface of the liquid when in equilibrium at the place of meeting of liquid and solid is at right angles to the surface of the solid. The angle between the free surfaces of liquid and solid is acute or obtuse, according as the interfacial tension is positive or negative; its cosine being equal to the interfacial tension divided by the free-surface tension. The greatest possible value the interfacial tension can have is clearly the free-surface tension, and it reaches this limiting value only in the, not purely static, case of a liquid resting on a solid of high thermal conductivity, kept at a temperature greatly above the boiling point of the liquid; as in the well-known phenomena to which attention has been called by Leidenfrost and Boutigny. There is no such limit to the absolute value of the interfacial tension when negative, but its absolute value must be less than that of the free-surface tension to admit of equilibrium at a line of separation between liquid and solid. If minus the interfacial tension is exactly equal to the free-surface tension, the angle between the free surfaces at the line of separation is exactly 180°. If minus the interfacial tension exceeds the free-surface tension, the liquid runs all over the solid, as, for instance, water over a glass plate which has been very perfectly cleansed. If for a moment we leave the center of the earth, and suppose ourselves anywhere else in or on the earth, we find the liquid running up, against gravity, in a thin film over the upper part of the containing vessel, and leaving the interface at an angle of 180° between the free surface of the liquid and the surface of the film adhering to the solid above the bounding line of the free liquid surface. This is the case of water contained in a glass vessel, or in contact with a piece of glass of any shape, provided the surface of the glass be very perfectly cleansed.

When two liquids which do not mingle, that is to say, two liquids of which the interfacial tension is positive, are placed in contact and left to themselves undisturbed by gravity (in our favorite laboratory in the center of the earth suppose), after performing vibrations subsiding in virtue of viscosity, the compound mass will come to rest, in a configuration consisting of two intersecting segments of spherical surfaces constituting the outer boundary of the two portions of liquid, and a third segment of spherical surface through their intersection constituting the interface between the two liquids. These three spherical surfaces meet at the same angles as three balancing forces in a plane whose magnitudes are respectively the surface tensions of the outer surfaces of the two liquids and the tension of their interface. Figs. 2 to 5 illustrate these configurations in the case of bisulphide of carbon and water for several different proportions of the volumes of the two liquids. (In the figures the dark shading represents water in each case.) When the volume of each liquid is given, and the angles of meeting of the three surfaces are known, the problem of describing the three spherical surfaces is clearly determinate. It is an interesting enough geometrical problem.

If we now for a moment leave our gravitationless laboratory, and, returning to the Theater of the Royal Institution, bring our two masses of liquid into contact, as I now do in this glass bottle, we have the one liquid floating upon the other, and the form assumed by the floating liquid may be learned, for several different cases, from the phenomena exhibited in these bottles and glass beakers, and shown on an enlarged scale in these two diagrams (Figs. 6 to 8), which represent bisulphide of carbon floating on the surface of sulphate of zinc, and in this case (Fig. 8) the bisulphide of carbon drop is of nearly the maximum size capable of floating. Here is the bottle whose contents are represented in Fig. 8, and we shall find that a very slight

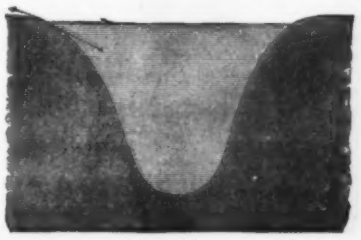


FIG. 8.

vertical disturbance serves to submerge the mass of bisulphide of carbon. There, now it has sunk, and we shall find when its vibrations have ceased that the bisulphide of carbon has taken the form of a large sphere supported within the sulphate of zinc. Now, remembering that we are again at the center of the earth, and that gravity does not hinder us, suppose the glass matter of the bottle suddenly to become liquid sulphate of zinc, this mass would become a compound sphere like the one shown on this diagram (Fig. 3), and would have a radius of about 8 centimeters. If it were sulphate of zinc alone, and of this magnitude, its period of vibration would be about 5½ seconds.

Fig. 9 shows a drop of sulphate of zinc floating on a wineglassful of bisulphide of carbon.

In observing the phenomena of two liquids in con-

* This sum for brevity I henceforth call simply "the curvature of the surface" at any point.

† See paper by Lord Rayleigh in *Pro. Roy. Soc.*, No. 196, May 5, 1879.

tact, I have found it very convenient to use sulphate of zinc (which I find, by experiment, has the same free surface tension as water) and bisulphide of carbon; as these liquids do not mix when brought together, and, for a short time at least, there is no chemical interaction between them. Also, sulphate of zinc may be made to have a density less than, or equal to, or greater than that of the bisulphide, and the bisulphide may be colored to a more or less deep purple tint by iodine, and this enables us easily to observe drops of any one of these liquids on the other. In the three bottles now before you, the clear liquid is sulphate of zinc—in one bottle it has a density less than, in another equal to, and in the third greater than the density of the sulphide—and you see how, by means of the colored sulphide, all the phenomena of drops resting upon or floating within a liquid into which they do not diffuse may be observed, and, under suitable arrangements, quantitatively estimated.

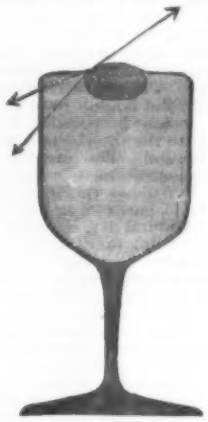


FIG. 9.

When a liquid under the influence of gravity is supported by a solid, it takes a configuration in which the difference of curvature of the free surface at different levels is equal to the difference of levels divided by the surface tension reckoned in terms of weight of unit bulk of the liquid as unity; and the free surface of the liquid leaves the free surface of the solid at the angle whose cosine is, as stated above, equal to the interfacial tension divided by the free surface tension, or at an angle of 180 degrees in any case in which minus the interfacial tension exceeds the free surface tension. The surface equation of equilibrium and the boundary conditions thus stated in words suffice fully to determine the configuration when the volume of the liquid and the shape and dimensions of the solid are given. When I say determine, I do not mean unambiguously. There may, of course, be a multiplicity of solutions of the problem; as, for instance, when the solid presents several hollows in which, or projections hanging from which, portions of the liquid, or in or hanging from any one of which the whole liquid may rest.

When the solid is symmetrical round a vertical axis, the figure assumed by the liquid is that of a figure of revolution, and its form is determined by the equation given above in words. A general solution of this problem by the methods of the differential and integral

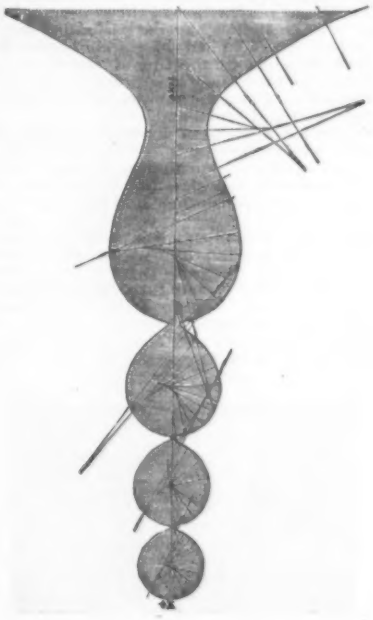


FIG. 10.

calculus transcends the powers of mathematical analysis, but the following simple graphical method of working out what constitutes mathematically a complete solution occurred to me a great many years ago.

Draw a line to represent the axis of the surface of revolution. This line is vertical in the realization now to be given, and it, or any line parallel to it, will be called vertical in the drawing, and any line perpendicular to it will be called horizontal. The distance between any two horizontal lines in the drawing will be called *difference of levels*.

Through any point, N, of the axis draw a line, N P, cutting it at any angle. With any point, O, as center on the line, N P, describe a very small circular arc through P P′, and let N′ be the point in which the line of O P′ cuts the axis. Measure N P, N′ P′, and the difference of levels between P and P′. Denoting this last by δ, and taking a as a linear parameter, calculate the value of

$$\left(\frac{\delta}{a^2}+\frac{1}{OP}+\frac{1}{NP}-\frac{1}{N'P'}\right)^{-1}$$

Take this length on the compasses, and putting the pencil point at P′, place the other point at O′ on the line P′ N′, and with O′ as center describe a small arc, P′ P″. Continue the process according to the same rule, and the successive very small arcs so drawn will constitute a curved line, which is the generating line of the surface of revolution inclosing the liquid, according to the conditions of the special case treated.

This method of solving the capillary equation for surfaces of revolution remained unused for fifteen or twenty years, until, in 1874, I placed it in the hands of Mr. John Perry (now Professor of Mechanics at the City and Guilds Institute), who was then attending the Natural Philosophy Laboratory of Glasgow University. He worked out the problem with great perseverance and ability, and the result of his labors was a

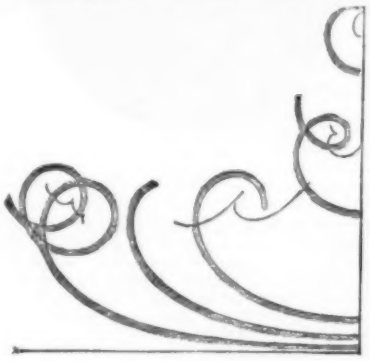


FIG. 11.

series of skillfully executed drawings, representing a large variety of cases of the capillary surfaces of revolution. These drawings, which are most instructive and valuable, I have not yet been able to prepare for publication, but the most characteristic of them have been reproduced on an enlarged scale, and are now on the screen before you. Three of the diagrams, those to which I am now pointing (Figs. 10, 11, and 12), illustrate strictly theoretical solutions—that is to say, the curves there shown do not represent real capillary surfaces—but these mathematical extensions of the problem,

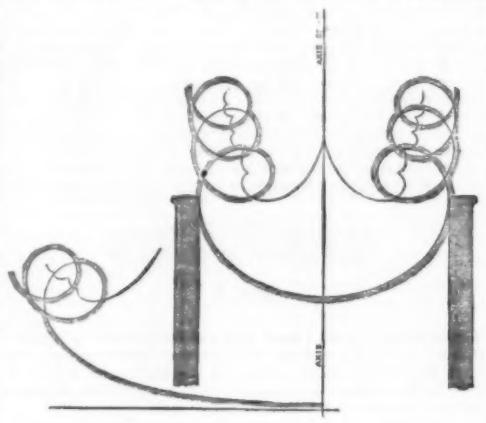


FIG. 12.

while most interesting and instructive, are such as cannot be adequately treated in the time now at my disposal.

(To be continued.)

ANTIFEBRIN—A NEW ANTIPYRETIC.

In the "Centralblatt für klinische Medicin" for August 14, Dr. A. Cahn and Dr. P. Hepp, assistants at Kussmaul's clinic at Strassburg, bring forward a new antipyretic agent that, if further experience bears out their statements, is somewhat remarkable. They state that the substance itself is not a new one, being the neutral principle known as acetanilide or phenylacetamide, the formula of which they give as $C_6H_5NHC_2H_3O$. The formula may otherwise be written $C_6H_5.N.(C_2H_3O).H = C_8H_9NO$. It is a white, crystalline, odorless powder, producing a slight burning sensation when placed on the tongue, almost insoluble in cold water, more readily soluble in hot water, and freely soluble in alcoholic liquids, including wine. It melts at 113° C., and boils unchanged at 293°. Besides possessing neither acid nor basic properties, it is indifferent to most reagents. Although closely related to aniline chemically, it was found not to cause poisonous effects when given to dogs and rabbits in comparatively large doses, nor did it affect their temperature.

On the human subject the authors have tried it in eight cases of typhoid fever, five of erysipelas, two of acute articular rheumatism, four of pulmonary phthisis, and one case each of pulmonary abscess, leucæmia with fever, pyæmic fever consequent on cystitis and bed sore, septicæmia, and ambulant pneumonia. The doses varied from four to fifteen grains, and thus far no more than thirty grains has been given in the period of twenty-four hours. The size of the dose needed cannot be told beforehand; as with other antipyretics, it depends on the nature, severity, and stage of the disease and on the peculiarities of the individual, but a given amount, such as four grains, is said to produce the same effect as four times the quantity of antipyrine. The authors think it probable that decided remissions of fever are more likely to be produced by single large doses than by repeated small ones, although that has not yet been shown to be the case. Tabular statements are given of the temperature variations under the use of the drug in two cases of typhoid fever, a case of erysipelas of the leg with lymphangeitis, and one of pulmonary phthisis. In two of these records the comparative action of acetanilide and of antipyrine may be noted.

Ordinarily the effect of "antifebrin" begins to show itself within an hour, reaches its maximum in about four hours, and lasts from three to ten hours, according to the size of the dose, but usually, provided the temperature has been brought down to or below the normal point, from six to eight hours. No chills have yet been observed, but, as in the case of antipyrine, in a few instances the patients felt cold. Hand in hand with the fall of temperature goes a notable lowering of the frequency of the pulse, associated with an increase in its volume, as ascertained with the sphygmograph. No unpleasant effect on the digestive organs has been observed; in a few instances the appetite returned, probably as a result of the temporary freedom from fever. In still other cases unusual thirst and decided diuresis were manifest during the remission. None of the patients complained of the drug; their general condition was perfectly good during the hours that they were free from fever. In one of the cases of rheumatism the articular pain, which had been severe, was allayed *pari passu* with the fever. At first the experimenters felt somewhat anxious on account of a pronounced cyanosis of the face and extremities in some of the patients, but this gradually disappeared and they ceased to regard it with apprehension. In a few cases, as in the experiments on animals, the patients fell into a tranquil sleep during the remission.

Besides the efficiency of the drug in comparatively small doses, its advantages are said to be that it does not disturb the stomach, that the sweating it causes is relatively moderate, and that it is cheap. The authors warn their readers against the use of an impure article. They also mention as a matter of theoretical interest the fact that, while the other antipyretics are either phenols (such as carbolic acid, hydroquinone, resorcin, and salicylic acid) or bases of the quinoline group (including quinoline, kairine, antipyrine, thalline, and quinine), we have in acetanilide an indifferent body of widely different constitution. The authors have experimented with the acetyl derivatives of toluidine and naphthylamine, benzanilide, salicylanilide, and some other complex compounds, which they promise to report upon hereafter.—*N. Y. Med. Jour.*

THE EFFECT OF LIGHTNING ON HUMAN BEINGS.

The effect which a stroke of lightning exercises on human beings has, no doubt, been often seen and described, but there is nevertheless much about it that is obscure. At the last meeting of German scientists at Hamburg, Dr. Heufner described certain cases which had come under his immediate notice, whereby some exceedingly remarkable physical effects of being struck by lightning were demonstrated. The principal contents of his report were as follows:

Sunday, July 13, 1885, a horse race was to take place at Barmen, to which a number of spectators flocked, in spite of an approaching thunderstorm. The course was inclosed with canvas stretched between poles in the ground, and as this wall afforded shelter against the wind and rain, which soon began to play, the spectators crowded against it. Suddenly a stroke of lightning descended, split two poles, tore away a large portion of the canvas, and felled twenty persons to the ground. Four of these were killed on the spot, and sixteen recovered consciousness in the space of a few minutes to an hour. The greater number of the sufferers were treated by Dr. Heufner, and from the others he received detailed statements. According to those who had at once rushed to the assistance of the persons struck, their faces bore an ashen color, their countenances were distorted, and the extremities cold as ice.

One lady, severely struck, felt, on regaining consciousness, an intense giddiness, "as if a wheel spun round in her head." She remained almost insensible till the following day, complaining greatly of weakness and pains in the limbs. Her legs were for several hours pale and cold, and insensible to touch, but in the sole of the foot she felt stinging pains. Behind the left ear, as far as the shoulder, ran a broad, irregular burn or scorch, in the center of which the skin had become hard as leather. Smaller burns and red spots were found on the right breast and the right arm. By the sole of the foot, on both sides, there were circular grayish-white spots with perforated centers, surrounded by lacerated and fatty scorched masses of the epidermis. These spots were situated at the edge of the toes, and showed little reaction during the first few days, whereas the burns on the upper parts of the body began to swell on the following day. In shape they reminded one of the hole which an electric spark makes in a piece of cardboard. By the sole of the foot of one man there were no less than twenty-four apertures of various kinds, and a corresponding number was found on the boot of the sufferer. All the holes were also in this case situated in the lower edge of the upper boot, only very fine ones being found in the actual sole. Hardly bigger were the holes Dr. Heufner found in the boots of another of the sufferers he examined, and he says: "It seems remarkable that lightning possessing the power of striking a man dead on the spot should be able to find an outlet through such tiny openings." With persons who wore shoes studded with metal knobs, there were no holes in the soles, as the former had doubtless acted as conductors. The damage made to the clothes of the sufferers was, on the whole, very small, but in the spots where the body bore burns, the coat and waistcoat showed small round holes half a centimeter in diameter. In the lining and the underclothing the holes increased in size, those in the shirt being as big as a shilling. In the hat of a boy there were three holes through the felt, about the size of a quill, while those in the lining were much larger. The hat, with its many perforations, demonstrated that the lightning had not descended in a single stroke, but in several.

The great increase in the destruction of the lining and inner garments is doubtless due to the circumstance that the electric current encounters a considerable degree of resistance through the non-conducting

qualities of the epidermis, which causes it to develop its greatest energy in this locality. It is also the resistance of the epidermis which causes the sudden and violent rupture of the skin, resulting in great injury to the same. Except those who were lightly struck, having only solitary burns or red spots, all the others had on the upper part of the body several burns of various sizes and irregular shape, whence red streaks radiated more or less over the body and limbs, and which after a while became covered with a crust. In some cases the hair on the skin was singed in a streaky manner, clearly proving that the lightning had passed across the skin; in others the streaks formed tooth shaped and bifurcated figures, such as are drawn in text books of physics for illustrating the so-called lightning figures.

Quite different was the injury done to the feet, and, may be, this difference between the wounds of the upper and lower parts of the body is due to a polar variation of the electric current. It is, we know, a fact that the positive pole affects the human body differently from the negative.

When the current reaches the moist part in the interior of the body, it may, without difficulty and without doing much damage, strike in all directions; this applies chiefly to the brain, the spine, and the eye, which are some of the best conductive parts of the body. It is for this reason that a stroke of lightning hitting the head is not always mortal, and that the exterior apparent injury shows a strong contrast to the intact state of the skull and brain. This was, for instance, the case with a boy fourteen years of age, who, in the middle of the forehead, just under the hair, had a burn about the size of a shilling. Four days after the catastrophe, the boy—whose skin on the forehead and upper eyebrows was very red and swollen, and whose eyelashes were singed—presented a frightful spectacle. He showed every sign of a great shock to the brain, the closing scenes of the race having entirely disappeared from his recollection, while he also, during the same period, suffered greatly from vomiting, and was for several weeks in a very low state, *but he suffered no permanent injury to the brain whatever from the stroke.*

Besides the injury to the head, this boy had for several months a burn on the upper rib, whence an incrusted scar ran behind, and, parting into two streaks above the loins, continued down the back of both legs to the heel. His terribly injured feet were at first very cold, remaining benumbed for hours at a time; then they became very swollen—phenomena which were also observed in the other sufferers, and which may perhaps be connected with cramp experienced at first, and the subsequent paralysis of the muscular system.

It is generally stated as an important fact that persons struck by lightning have no recollection of the occurrence. Lightning, with its enormous velocity, paralyzes and kills before its light can reach the ocular, or its sound the oral, nerves, and the victim thus become conscious.

The lady referred to above would not believe, when told so in the hospital, that she had been struck by lightning; and a man who, on recovering, hearing her cries for help, attempted to rush to her assistance, found to his great surprise that he could not move a muscle. This again seems to explain the strange circumstance that those who have been struck by lightning, as a rule, show no fear or excitement, but rather apathy.

Several of those struck in this case had, however, some recollection of being hit, having, doubtless, first suffered unconsciousness a moment later. One of them related that he had felt being struck, and sinking down with a sensation as of being torn to pieces. Another stated that he felt a blow in the neck as from a thick stick, and he became always afterward very frightened during a thunderstorm. A third, who still recollected seeing a man falling ashy pale by his side, compared the shock he felt when struck to the blow of a sledge hammer on an anvil without its rebound.

MALIGNANT PUSTULE.

By D. W. FOSTER, M.D.

ON July 12, 1885, T. L. consulted me in regard to his finger. I found a bulla, with bluish head on an elevated base, which I recognized as what is commonly called here "charbon," or "bouton malin." I suppose *pustula maligna* would be more appropriate. It sometimes decimates horses and cattle on the prairies,* and not unfrequently human beings fall victims to it. If not taken in time and properly treated, it destroys life in both man and beast, sometimes in a few hours. This patient informed me that he had skinned a dead ox or two nine days before that, and the next day he discovered a little pimple on his finger, but never thought seriously of it. When I first saw it, the whole blood was poisoned with the virus; the arm was swollen, and soon the areolar tissue was charged full of yellow fluid; and he died, as I supposed he must at that late day.

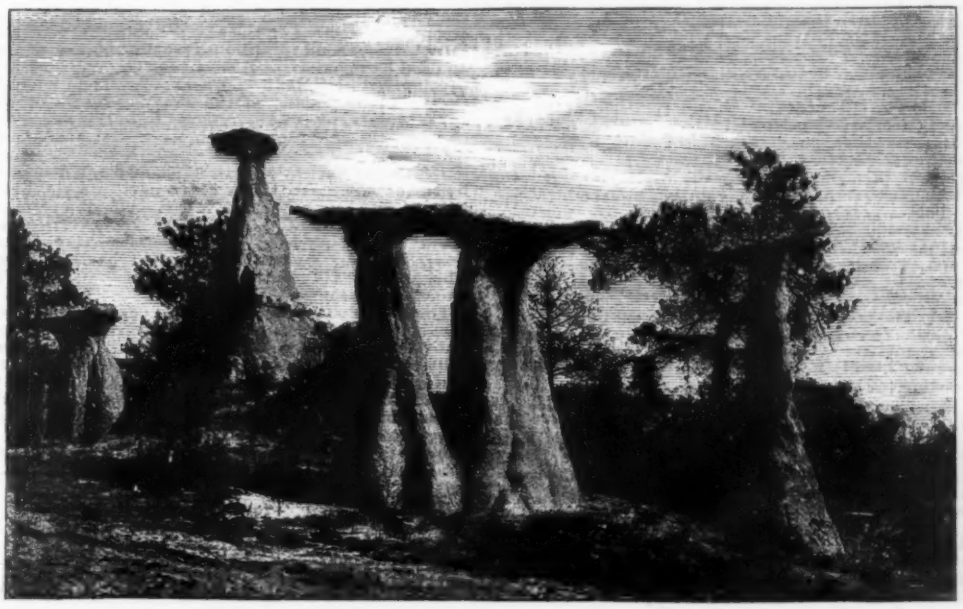
On June 26 of this year, a man called at my office to show me his finger, which was all right when he went to bed the night before, but on arising that morning, he found on his finger a small papule with a hard, red base, with pain along the lymphatics. When he consulted me, his finger was somewhat swollen, and the top of the pimple purplish. I introduced a thumb lancet down to the bone without giving pain or drawing blood, but I enlarged the opening until I touched life, sensitive tissue, when blood flowed from some veins divided, but not from the capillaries of the part involved. I sharpened the flat end of a stick, which I turned with a boring motion down in the bottom of the opening, which I filled with pure carbolic acid, and continued boring with the wide end of the stick, and bringing the pure carbolic acid thus in contact with the cavity I formed, and washing it out until I thought I had destroyed the poison. Then I packed the cavity with lint saturated with carbolic acid, and gave large doses of alcohol and liquor ammoniæ fortior., to be taken every two or three hours, until he felt no pain in the lymphathics. I instructed him to return next morning. He reported next morning that the fourth dose of the alcohol and ammonia mixture relieved the pains up the arm. His finger had not troubled him at all. I removed the packing, and found the cavity black and dry. I filled the cavity again, and ran a painted bistoury in every direction from within to without—each time until he would flinch; and thus I brought the pure fluid carbolic acid in contact with the whole poisoned mass, even to touch the sound flesh. I again packed the cavity, and directed him to take a moderate dose of alcohol every four hours during the day, and return again next morning. Finding the poison arrested the next morning, I filled the cavity with ol. terebinthinæ, and packed it with lint again, after penetrating the dark portion in every direction from within the cavity out to sensitive tissue, and thus saturating the part with the spirits of turpentine. I gave him a mixture of equal parts spirits of turpentine and castor oil, to dress it with. A vegetable cholagogue, quinine and iron, finished the treatment successfully.

I have treated, perhaps, a dozen cases in the human subject and in horses. One of my buggy horses ate as heartily as usual one night; but the next morning I found him nearly dead—trembling, with his eyes staring, and his nostrils dilated, breathing laboredly, and his four feet spread out to support him from falling. He had charbon on his forefoot. I treated him as the case just detailed, and he got well. I had to repeat the ammonia and alcohol, at first, in large doses every four hours, then at longer intervals every time, until he ceased to need it. It was wonderful to see him snatched from the jaws of death. In an hour after treating him he went to grazing, until the effects of the stimulants died out, when the same distressing symptoms began to return, to be again relieved in less than an hour, when he resumed his grazing. I think one of my own children was inoculated by a mosquito. She went to bed well, and next morning she was *in extremis*, with a bluish bleb on the leg below the knee. There were some carcasses on the prairie not very distant; and I think a mosquito or other insect that had been sucking the dead animal inoculated the child, perhaps, after daylight.—*The Polyclinic.*

* At this time it is prevailing fatally among stock in an adjoining parish.

A VISIT TO MANITOU.

A CORRESPONDENT of *Engineering*, who attended the recent Colorado Convention of the American Society of Civil Engineers, thus describes a visit to Manitou and other remarkable places:



GROUP OF ROCKS IN THE GARDEN OF THE GODS.

The air is cool and balmy, and the adjacent wonders and the excellent hotels render Manitou one of the finest watering-places in the world. The mineral springs are effervescing, and consist, one of soda, one of sulphur, and one of iron. This latter bursts from the earth at a temperature of ice water, and is thoroughly impregnated with iron; in holding it up to the light, bubbles rise as they do in a glass of champagne. It is consoling and strengthening to all partakers, and the hotel where it is a specialty is one of the best at Manitou.

The first thing to be explored is the "Garden of the Gods," situated near the town; it is full of enormous bowlders, which have by the action of the water been worn into fantastic shapes. This locality was undoubtedly the source of an immense lake, and these bowlders show plainly how the waves have worn their sides and have earned for them the titles which posterity has affixed. There was something rather awe-inspiring as we gazed on these relics of an age far beyond the memory of man, and the reflection of what scenes and what prehistoric monsters these quaint and curious stones had witnessed was forced on the beholder.

The grandest sight of all was the view of Pike's Peak through the gateway of the "Garden of the Gods."

These rocks, which are of sandstone, rise on either side over 400 ft., and the white rock in the foreground only a short distance from them is limestone. On entering the gateway rocks of the most fantastic appearance are seen; nearly one hundred are to be selected, which have various names due to their fancied resemblances, the favorite names being the Sphinx, the Cathedral Spires, which look like those of Milan, the Kiesing Camels, etc.

At the approach from Manitou a large balanced rock stands as a sentinel who would challenge any sacrilegious visitor. It looks as though the slightest push would precipitate it down the steep incline it dominates, and yet it probably stood where it now rests when the earth was young, and may stand there till the final disruption of all things.

If this strange spot, where nature seems to have sported with huge masses of stone, looks attractive by day, its weird forms look even more uncanny at night, and the silvery light of the moon enhances their strangeness and magnifies their mysterious influence. As this was the proper season, every one had the moonlight view, and all were impressed with the grandeur of this most picturesque spectacle.

The party for Pike's Peak started early, and made the ascent and descent in twelve hours. The signal station at Pike's Peak is a most dreary place, and no one who is detailed there is an object of envy.

The next day a party started for the Cheyenne Canon, and it may be said that the millionaires of Manitou will be its livery stable men. Not that their charges are so exorbitant, but their arrangements are so complete for preventing the traveler from seeing more than one thing in a day. For instance, Cheyenne Canon is by way of Colorado Springs sixteen miles distant, but why one must go by the Springs was a question promptly asked of our driver. He said there was no other way, although a road seemed to go in the direction of the canon from the "mesa" or tableland. After we had gone by the way of the Springs, which occupied the day till 3 P. M., and was very much like going to Ludgate Hill from Charing Cross by way of High Holborn, our driver discovered a short cut for the return, which landed us in Manitou in 1¾ hours. As the team was hired by the day, one can apply the reasoning, since we were told we must take it all day, as it could not be done in less time. Nevertheless, in full view of all these facts, the writer unhesitatingly says, it paid.

At the summit of this cliff is the grave of "H. H.," who has so abused our beneficent Government for its dealings with the Indians, and has thereby, in the writer's view, simply shown herself to be an extremely silly and impracticable woman. However, he is a skeptic on her merits and has yet to see one of her books which in his judgment will repay perusal, her last, "Ramona," being more impossible than any other.

On the day following, we went to Ute Pass and saw the Rainbow Falls.

The falls are surprisingly beautiful, and the horses no doubt thought the road up the pass did not warrant any display of enthusiasm. It was a fearfully steep pull, but at the summit was the celebrated "Cave."

The writer is pretty well "up" in caves (certainly we all were on this at the elevation). Mammoth and Luray caves have both been visited by the Society; the latter stands without a peer for beauty, but the Manitou Cave is certainly remarkably fine and well worth the climb it costs and the one dollar entrance fee. The stalactites are semi-translucent, of great beauty, and of marvelous shapes. The "organ" is composed of a series of them alongside of each other, and when struck each has a different note. The result is that a skillful player can perform on them with great effect. There were also many other beautiful and wonderful stalactites and stalagmites.

On leaving Ute Pass, we rode to William's Canon.

In some places this was so narrow that the whiffletrees scraped the walls on either side. The cliffs towered up above us in great magnificence and to dizzy heights, while the action of the river, which had undoubtedly flowed through it at some time, had cut the rocks into the most fantastic shapes and castellated appearance. This too has its subterranean cave, but we took their word for it, and they did not take our dollar, so we returned to our hotel richer in pocket and with a new supply of faith. One thing more completed the Manitou trip, to our great regret, and that was the swimming bath. This structure is very picturesque and very conveniently arranged. One can take a most luxurious hot soda bath, and then plunge into the swimming tank some 200 ft. by 100 ft. and about 5½ ft. deep. When he has finished and taken a good drink of the soda spring, he will feel so invigorated that he will unhesitatingly say, "Life is worth the living."

That night we again resumed our train of hotel cars and sleepers, and three days later rolled into the Grand Central Depot in New York, a wiser and it is to be hoped a better party.

The train kept up its record for speed all the way, the rate rising in some instances to about 70 miles an hour. The last 18 miles took 18 minutes, counted from stop to stop.

ALUM gives excellent results when it has been found desirable to clarify muddy or turbid waters. Ammonia water will precipitate all iron in solution, but is not likely to be as successful a clarifying agent.

THE EARTH'S SECOND ROTATION.

To the Editor of the Scientific American:

I venture to ask for space in your paper to call the attention of astronomers, geometricians, and reasoners to the following important and interesting facts:

The three principal movements of the earth have been described during the past three hundred years as—

1st. A daily rotation on, or round, an axis.

2d. A revolution round the sun, annually.

3d. A conical movement of the axis of daily rotation, round the pole of the ecliptic as a center, which conical movement is said to be completed in about 25,800 years.

Having devoted many years to the investigation of this third movement, I claim that to describe this as *a* conical movement of the earth's axis is a vague and incorrect definition. A conical movement of the axis of a sphere can be produced by a multitude of movements in the sphere itself, each of which will produce very different movements in other parts of the sphere.

A conical movement of the *axis* of a sphere cannot be produced without causing the center of gravity of this sphere to alter its position as regards objects outside the sphere. Consequently, if we attribute such a movement to the earth, we cannot produce this without throwing the center of gravity of the earth out of its orbit.

After an examination of every available fact connected with the subject, I have come to the following conclusions, which I trust will be not hastily rejected or ignored, because they are slightly different from that which has been previously admitted, but will be fairly examined and tested, and their efficiency, as explanations of known facts, duly noted:

1st. That the earth has a second or slow rotation during a period of 31,580 years.

2d. That the axis of this slow rotation passes through the center of gravity of the earth, but is not fixed as regards other parts of the earth, but is fixed as regards the sphere of the heavens.

3d. The axis of this slow rotation is inclined at an angle of 29° 25′ 47″ to the semi-axis of daily rotation, and intersects the daily axis at the center of gravity of the earth.

4th. The North Pole of the axis of slow rotation is located 6° from the pole of the ecliptic, 29° 25′ 47″ from the pole of the heavens, and at the date 2395 A. D. the pole of second rotation, the pole of the ecliptic, and the pole of the heavens will be on the same great circle of right ascension.

5th. The effects of this second rotation can be most easily comprehended by giving to a common globe a rapid rotation round the axis of daily rotation, and at the same time giving to the stand on which the globe rests a slow rotation, the rapid rotation being from left to right, the slow rotation from right to left.

The effects of this slow rotation are marvelous as explanations of known facts, the principal effects being:

1st. To cause the semi-axis of daily rotation to make a conical movement, the cone being completed in 31,580 years.

2d. The pole of the heavens is caused by this second rotation to change its position annually to the amount of about 20·1″; the North Pole moving at present toward about 2° of right ascension, the South Pole moving toward about 182° right ascension.

3d. The precession of the equinox is produced by this change in direction of the semi-axis.

4th. The slight decrease in the obliquity of the ecliptic, now known to exist, is accounted for by this second rotation, inasmuch as the pole of the heavens is not caused to move in a circle round the pole of the ecliptic *as a center*.

5th. The second rotation causes the earth's *semi-axis* to trace the course named above, which results in causing the pole of the heavens to vary its distance from the pole of the ecliptic, between the limits of 23° 25′ 47″ and 35° 25′ 47″, during 15,790 years.

6th. From the last-named results, it follows that, at the date about 13,500 B. C., the Arctic Circle reached to 54° 34′ latitude in each hemisphere, and a part of Westmoreland and the whole of Scotland were within the Arctic Circle, and the glacial epoch of geology is explained.

7th. From a knowledge of this second rotation of the earth, any geometrician can *calculate* the value of the obliquity of the ecliptic for any date, past, present, or future, without any reference to observations.

8th. The pole of the heavens and the pole of the earth are not the only two points affected by this second rotation, but every locality on earth will have its zenith and meridian affected thereby, and *differently affected according to its latitude.*

9th. Every zenith of every locality will be differently affected, during *different times of the year*, by this second rotation in a manner which any geometrician can work out.

10th. The right ascension and declination of various stars will vary in a manner not accounted for, either by precession or nutation, in consequence of the second rotation, and the majority of these variations are accounted for by the same fact.

11th. The axis of daily rotation and the axis of slow rotation both pass through the center of gravity of the earth, and this center of gravity, therefore, moves uniformly round the same orbit, undisturbed by either movement.

12th. The present accepted theory of *a* conical movement of the earth's axis is not only vague, but cannot occur unless the center of gravity of the earth is thrown out of its orbit.

13th. The present accepted theory, that the pole of the heavens traces a circle round the pole of the ecliptic *as a center* (see Herschel's Outlines of Astronomy, article 316) is a geometrical impossibility, when we know that these two poles have gradually decreased their distance during the past 2,000 years, as proved by the decrease in the obliquity.

14th. A multitude of facts known by observation to occur in connection with astronomy, each of which now requires a separate theory, are fully explained by this second rotation. Consequently, this second rotation occupies a corresponding position to that which the daily rotation occupied when the epicycles of Ptolemy were accepted as explanations of the rising and setting of the various celestial bodies.

15th. The second rotation is due to a mechanical law, affecting a sphere, which, being suspended in space, rotates rapidly, and at the same time revolves round a central body.

These are facts which I submit for consideration, and when they are admitted, simplicity will take the place of complexity. The climatic changes known to geologists receive an explanation, the mysterious changes known to astronomers to occur in their zeniths receive an explanation. The so-called proper motion of the fixed stars is explained by the changes in the zenith and meridians of various observatories. The endless observations of observers, and the reduction of these by computers, become complications of the past. The earth's climatic changes can be read back for thirty thousand years, and more.

Results can be obtained by calculation now utterly beyond the powers of anything but repeated observation. Geometrical impossibilities can be set aside, and the laws of gravitation need not be ignored when the second rotation of the earth is admitted. I ask no more than a fair and searching investigation of my statement. Test the fact of a second rotation, such as that which I have named, and note the result. When the fact is admitted, I have much more to state, as regards details and causes, also the changes which must have occurred in the dark ages of the past. During the past forty or fifty years, astronomers have devoted their attention almost entirely to the perfecting of their instruments, and to making accurate observations therewith.

The great advances made in observational astronomy, and the minute attention paid thereto, are probably the causes which have led to the singular inconsistency mentioned in 12th and 13th above, having been entirely overlooked; the baneful influence of blindly following authorities having prevented the errors in first principles from being even remarked upon or noticed. This second rotation of the earth is consequently a question on which geometricians and reasoners may probably be better qualified to form a correct opinion than the routine astronomer. Any way I claim it is a fact, and I make this claim after twenty years of searching and investigation, and I now submit it for criticism, as one of great importance, enabling us, as it does, not only to simplify astronomy, and to explain mysteries therein, but to read the past history of the earth during 31,000 years at least. The present accepted movement of the axis is impossible geometrically. The second rotation presents no impossibilities, and can be demonstrated mechanically, and is verified by observed facts, both in astronomy and in geology. Only a small portion of the singular results of this second rotation has been referred to in this letter, but the elements of the problem must be first understood, before any further advances can be made. A conical movement of the earth's axis is claimed as a first cause by the orthodox astronomy of the day. I state that it is not a first cause, but that it is *one* effect of a second rotation of the earth during 31,580 years. The circle traced on the sphere of the heavens each day, by the zenith of every locality, is not a first cause, it is one effect of the daily rotation of the earth on its axis. The two cases are somewhat similar.

The conical movement of the semi-axis of daily rotation is the most manifest effect of the *second* rotation, but the rapid daily rotation, although it has successfully concealed the cause of the other effects, does not and cannot eliminate them. They are exhibited in the so-called proper motion of the fixed stars, in the slight annual changes in the zeniths and meridians of our observatories, and in the climatic changes known to geologists, which changes have hitherto been inexplicable.

A. ADYNORS.

THE NEW STRAWBERRY INSECT.

THE depredations of the insect were first observed in Staten Island, New York, in June last, causing grave apprehensions among the strawberry growers there; it appeared about the same time in some parts of Michigan. The Entomological Bureau of the Department of Agriculture in Washington promptly took steps to investigate the subject, and the Chief of the Bureau, Prof. C. V. Riley, proceeded in person to inquire into the character and extent of the injury, with the view of suggesting measures for its abatement.

This new pest was found to be a small *curculio*, which has been known to entomologists in this country for more than fifty years under the name of *Anthonomus musculus*. It is a small snout beetle, which measures, including the beak or snout, only one-tenth of an inch. The body is of a dull reddish color, punctured, and dotted and spotted with white; different specimens vary much in their general hue, some being found very dark, occasionally almost black. Heretofore it has been met with only in the collections of entomologists, who have found it to be very generally distributed throughout the Middle, Southern, and Western States, and also in Canada, but nowhere in any particular abundance, and no one had thus far suspected it to be guilty of any injurious propensities; indeed, little or nothing has been known of its habits or history.

A few days after its appearance in this new role—as a strawberry pest—was announced in the United States, I received a package from Mr. J. C. Morgan, an energetic strawberry grower in Barrie, Ontario, intimating that a destructive insect which had never been noticed before was seriously injuring some of the strawberry beds in that neighborhood, an insect which seemed to have a special liking for that variety of strawberry known as the Sharpless. When speaking of this pest, Mr. Morgan says: "It climbs up the flower stalk, selects one flower, and deliberately and quickly cuts it off; as soon as the flower falls or hangs over by a small thread, the insect crawls down, runs up the next stalk, and commences again. This performance is varied by puncturing the open blossom in several places, which said blossom will also come to grief. It is found in immense numbers on the Sharpless, slightly on the Wilson, and on no other berry as yet." On examination, this was determined to be the same species as that which had occurred on Staten Island and in Michigan. It is remarkable that this insect, never met with before in any great numbers, should have occurred in such abundance at points so distant from each other as Staten Island, N. Y., Michigan, and Barrie, Ontario, all about the same time, and not be reported as occurring at intermediate points. In the absence of further knowledge of the life history of this insect, we can only suggest as a remedy the use of Paris green and water, in the proportion of a teaspoonful of the poison to two gallons of water, which, if applied to the vines with a syringe when the beetles are troublesome, would probably destroy many of them.—*Wm. Saunders, London, Ontario.*

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TABLE OF CONTENTS.

PAGE

I. ASTRONOMY.—The Earth's Second Rotation.—By A. ADYNORS.—Suggestion of and arguments for the existence of a hitherto undetermined axis of rotation of the earth.—Use of this assumption in geodetic calculations. 8982

II. BIOGRAPHY.—E. S. Chesbrough, C.E.—Biographical note of the life of the eminent civil engineer, with portrait.—1 illustration. 8972

III. CHEMISTRY.—Etched Figures and Arrangements of Atoms. 8978
Examination in Chemistry.—New syllabus for chemical examination or lecture courses.—Full details of experiments and classified arrangement of subjects.—Of special importance to teachers of chemistry. 8976

IV. ENGINEERING.—Life and Profits of a Car.—By E. C. SPALDING.—A valuable summary of the earnings and expenses of freight cars on our railroads, showing how short the profitable period of running is. 8968
The Laia L. Bridge, Oporto.—Completion of the series of illustrations of this structure given in SUPPLEMENT, No. 557.—Further details of building operations and mounting of arch.—5 illustrations. 8967

V. ENTOMOLOGY.—The New Strawberry Insect.—By WILLIAM SAUNDERS.—Account of the *Anthonomus musculus* in his new role of strawberry pest.—Identification of specimen by Prof. C. V. Riley.—Suggestions for remedy. 8982

VI. MEDICINE AND PHYSIOLOGY.—Antifebrin.—A new antipyretic.—A febrifuge of very valuable properties.—Full report of its effects, dose, and general qualities. 8980
Malignant Pustule.—By D. W. FOSTER, M.D.—Carbolic acid treatment of this complaint as applied to man and animals. 8981
The Effect of Lightning on Human Beings.—Diagnosis of several cases of lightning stroke by Dr. Heufner, of Germany. 8980

VII. METEOROLOGY.—Registering Barometers and Thermometers.—A very important article, containing full descriptions of a number of typical instruments of this type, now absolutely necessary for all well-equipped meteorological stations.—12 figures. 8974

VIII. MISCELLANEOUS.—A Visit to Manitou.—Account of scenery in the Garden of the Gods in Colorado.—The famous Manitou Cave.—1 illustration. 8981
An Old Time Fast Sailer.—A small vessel of the past generation of extraordinary speed.—Her performances and records. 8972
Floating Islands. 8969
The Galatea and Mayflower.—Description of the latest contestants for the Queen's Cup and of the international yacht races deciding its possession.—Full dimensions of both yachts.—6 illustrations. 8971

IX. NAVAL ENGINEERING.—The Farcy Gunboat.—A new vessel recently tried on the Seine; distinguished by ease in maneuvering.—2 illustrations. 8969
Torpedo Boats.—Description of small torpedo boats lately constructed for the Brazilian government by J. J. Thornycroft & Co., in use on South American lakes.—Speed, dimensions of engines, and methods of attack.—2 illustrations. 8968

X. PHYSICS.—Apparatus for Measuring the Compressibility of Gases at a High Pressure.—Description of apparatus and use thereof for effecting this determination, now of the greatest importance in physical work. 8973
Capillary Attraction.—By Sir WILLIAM THOMSON.—First instalment of a lecture treating this subject exhaustively, by the highest living authority in molecular physics.—12 illustrations. 8978

XI. PHOTOGRAPHY.—Printing Ink Photography.—Full account of the collotype process, now so successfully applied in Germany.—Formulas and all details. 8972

XII. TECHNOLOGY.—Mechanical Feeders for Wool Carders.—Various typical machines described and illustrated.—3 figures. 8969
The Cold Zone in Water Vessels.—By T. FLETCHER, F.C.S.—Further investigation of this important subject.—Interesting suggestions for experiments on the region between plane and solid body. 8967
Weaving School at Mulheim.—An account of a German manual training school, of peculiar interest at the present day, when the tendency of educators is so strongly in this direction.—1 illustration. 8975

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